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(54) Battery pack cooling system

(57) A cordless power tool (20) has a housing (22) which includes a mechanism (24) to couple with a removable battery pack (26). The battery pack (26) includes one or more battery cells (36) as well as a vent system (38) in the battery pack housing (34) which enables fluid to move through the housing (34). A mechanism (46, 48, 50, 52, 72, 76, 77, 84, 106, 108, 110, 132) is associated with the battery pack (26) to dissipate heat from the battery pack.

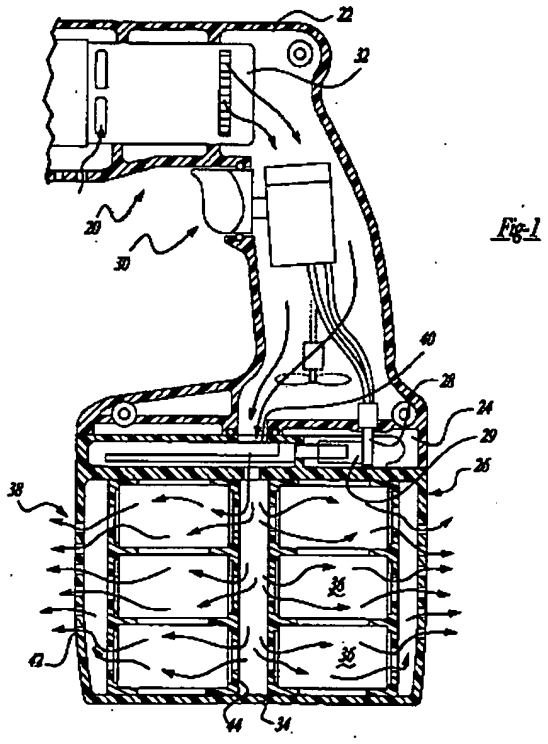

Fig-1

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Description

[0001] The present invention relates to battery cooling systems and, more specifically, to systems for cooling batteries for cordless power tools.

[0002] Cordless products which use rechargeable batteries are prevalent throughout the workplace as well as in the home. From housewares to power tools, rechargeable batteries are used in numerous devices. Ordinarily, nickel-cadium or nickelmetal-hydride battery cells are used in these devices. Since the devices use a plurality of battery cells, the battery cells are ordinarily packaged as battery packs. These battery packs couple with the cordless devices and secure to the device. The battery pack may be removed from the cordless device and charged in a battery charger or charged in the cordless device itself.

[0003] As the cordless power device is used, current flows through the batteries to power the cordless device. As current is drawn off the batteries, heat is generated within the battery pack. Also, during charging of the battery pack, heat is likewise accumulated during the charging process. The heat created during discharge of the batteries as well as charging of the batteries which, in turn, leads to increased temperatures, may have a severe effect on the life expectancy and performance of the batteries. In order for batteries to properly charge, the batteries must be below a desired threshold temperature and the differential temperature between the cells in the battery pack should be minimized. Likewise, if the batteries become too hot during use, battery life will be cut short. Also, if a battery is below a certain threshold temperature, it will be too cold to charge and must be warmed before charging. Thus, it is desirous to maintain batteries within a desired temperature range for optimum performance as well as optimum charging.

[0004] Further, battery packs typically contain some battery cells close to the outer walls of the pack, while some battery cells are surrounded by other battery cells. Those cells close to the outer walls have better thermal conductivity to the outside ambient than do the cells that are surrounded by other cells. When a battery pack is discharging on the cordless device, the amount of heat generated is approximately the same in each cell. However, depending on the thermal path to ambient, different cells will reach different temperatures. Further, for the same reasons, different cells reach different temperatures during the charging process. Accordingly, if one cell is at an increased temperature with respect to the other cells, its charge or discharge efficiency will be different, and, therefore, it may charge or discharge faster than the other cells. This will lead to a decline in the performance of the entire pack.

[0005] In accordance with a first aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple a removable battery pack. A removable battery pack has a housing with one or more cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat in the battery pack housing. This heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around cells as desired. Also, alternatively, a heat sink may be used to dissipate heat from the cells. Further, alternatively, a tan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack.

[0006] In accordance with a second aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple with a removable battery pack. A removable battery pack has a housing with one or more cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat from the battery pack. This heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around the cells with higher temperatures. Further, alternatively, a heat sink may be used to dissipate heat from the cells. Also, alternatively, a fan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack. A battery charger to charge the battery pack is also included. The battery charger has a mechanism to move fluid through the vent system of the battery pack housing. The charger may include a fan to force air through the battery pack vent system. Further, the battery pack may include a fan and in this case the charger may include a vent system to enable fluid to pass by the cell or cells in the battery pack housing.

[0007] In accordance with a third aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple with a removable battery pack. A removable battery pack has a housing with one or more cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat from the battery pack. This heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around the battery cells. Also, alternatively, a heat sink may be used to dissipate heat from the battery cells. Further, alternatively, a fan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack. Also, a battery charger to charge the battery pack is included. Here, an auxiliary fan is coupled with the charger or battery pack to force air through the charger or battery pack vent systems. The auxiliary fan is capable of moving fluid through the battery pack while the battery pack is secured with the charger.

[0008] In accordance with a fourth aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple with removable battery pack. A removable battery pack has a housing with one or more cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat from the battery pack housing. This heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around the battery cells. Also, alternatively, a heat sink may be used to dissipate heat from the battery cells. Further, alternatively, a fan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack. A heat pump is included to provide heating or cooling of the battery cells depending upon the temperature of the battery cells. Thus, the heat pump enables the battery cells to be cooled if they are above a desired temperature and to be heated if the cells are below a desired temperature to enable charging of the cells.

[0009] In accordance with a fifth aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple with a removable battery pack. A removable battery pack has a housing with a plurality of cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat or equalize temperatures in the battery pack. The heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around the cells with higher temperatures. Also, alternatively, a heat sink may be used to dissipate heat from the higher temperature cells. Further, alternatively, a fan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack. A sensing mechanism may be included to sense the temperature of the plurality of cells in the battery pack housing. The heat dissipator equalizes the temperature of the plurality of cells. The heat dissipator wicks heat from the hotter cells to ambient or to the other cells to equalize cell temperature within the housing.

[0010] In accordance with a sixth aspect of the invention, a removable battery pack has a housing with one or more cells in the housing. A vent system is in the housing to enable fluid passage through the housing. A mechanism is associated with the battery pack to dissipate heat from the battery pack. This heat removal from the battery pack reduces the battery pack charging time. The heat dissipating mechanism may include fluid directors to move fluid around cells. Also, alternatively, a heat sink may be used to dissipate heat from the cells. Further, alternatively, a fan may be used to force fluid through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack.

[0011] In accordance with a seventh aspect of the invention, a cordless power tool comprises a housing which includes a mechanism to couple with a removable battery pack. A removable battery pack includes a housing with one or more cells in the housing. A mechanism is in the battery pack housing coupled with the plurality of cells to equalize temperature of the plurality of cells. The mechanism may be a heat sink to equalize temperature of the cells in the housing. The heat sink may include an increased concentration of material in areas having higher temperature cells. Also, the heat sink may include a thermally conductive electrically insulating medium surrounding the cells, a base, and fins. Also, the battery pack may include apertures for dissipating heat.

[0012] In accordance with further aspects of the invention, several of the above features may be combined with one another to provide additional advantages. Additional objects and advantages of the invention will become apparent from the detailed description of the preferred embodiment, and the appended claims and accompanying drawings, or may be learned by practice of the invention.

[0013] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention and together with the description serve to explain the principles of the invention. In the drawings, the same reference numerals indicate the same parts.

[0014] Figure 1 is a partial cross-section view of a cordless power tool and battery in accordance with the present invention.

[0015] Figure 2 is a partial cross-section view of a battery pack in accordance with the present invention.

[0016] Figure 3 is a cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0017] Figure 4A is a cross-section view of another battery pack in accordance with the present invention.

[0018] Figure 4B is an elevation view of the battery pack of Figure 4A.

[0019] Figure 4C is a cross-section view of another battery pack in accordance with the present invention.

[0020] Figure 5 is another cross-section view of a battery pack in accordance with the present invention.

[0021] Figure 6 is an additional cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0022] Figure 7 is an additional cross-section view of a battery pack in accordance with the present invention.

[0023] Figure 8 is a cross-section view of an auxiliary fan module in accordance with the present invention.

[0024] Figure 9 is a perspective view of a charger in accordance with the present invention.

[0025] Figure 10 is a cross-section view of the auxiliary fan module coupled with the charger of Figure 9 in

accordance with the present invention.

[0026] Figure 11 is a cross-section view of another embodiment of the present invention of a charger of Figure 9.

[0027] Figure 12 is a cross-section view like that of Figure 8 of another embodiment of an auxiliary fan in accordance with the present invention.

[0028] Figure 13 is a perspective view of a battery cooler/heater in accordance with the present invention.

[0029] Figure 14 is a longitudinal cross-section view of Figure 13.

[0030] Figure 15 is a view like Figure 14 of an additional embodiment of the battery cooler/heater.

[0031] Turning to the figures, a cordless device is illustrated and designated with the reference numeral 20. The cordless device ordinarily includes a clamshell type housing 22. The housing 22 includes a mechanism 24 to couple with a portion of a battery pack 26. The cordless device 20 includes electrical elements 28 which couple with the battery pack electrical elements 29. Also, the device includes a trigger 30 which energizes the motor 32 within the housing 22.

[0032] The battery pack 26 includes a housing 34 which contains a plurality of battery cells 36 within the housing 34. Also, the housing 34 includes a ventilation system 38 which enables fluid to pass through the housing 34 and move around the cells 36 to dissipate heat from the plurality of cells 36 to the ambient air. The venting system 38 ordinarily includes at least one inlet 40 and at least one outlet 42. The inlet and outlet are ordinarily apertures or slots in the housing 34. Also, a channel 44 is formed within the housing 26 and aligned with the inlet 40 to distribute the fluid flow around the battery cells 36 so that all of the battery cells 36 are cooled. Preferably, the fluid flows coaxially with respect to the axes of the batteries 36. Thus, as fluid enters into the channel 44, the fluid is directed over the battery cells and does not pass over one cell to the next cell, etc., but is passed over a number of cells at one time so that the fluid passing through the housing is not warmed by the first cell and then passed over the second cell. However, fluid could be passed over the battery cells transversely with respect to the battery cells axes.

[0033] Turning to Figure 2, an additional embodiment of a battery pack is shown. The battery pack 26 is like that illustrated in Figure 1, including the housing 34, ventilation system 38 with inlet 40 and outlet 42. Also, cells 36 are positioned within the housing. Additionally, the battery pack includes one or more baffles 46, 48, 50 and 52. The baffles direct the fluid to specific battery cells 36. Ordinarily, the fluid is passed into channel 44 and distributed through the baffles 46 and 48.

[0034] Turning to Figure 3, an additional embodiment of a battery pack is shown. Battery pack 60 includes a housing 62 with a venting system 64 which enables fluid to pass around the battery cells 66. The ventilation system 64 includes at least one inlet 68 and at least one outlet 70. Also, the battery housing includes a fan 72. The fan 72 may include a motor 74 which may run off of the battery cells 36. Also, the fan motor 74 may run off of a charging circuit when the battery pack is in a charger. The fan 72 moves fluid through the battery pack inlet. The fluid is forced over the battery cells 66 and out the outlets 70. Thus, a positive pressure is created in the battery pack as fluid flows through the battery pack 60. However, a negative pressure could be created in the battery pack sucking fluid through the battery pack. The channels 73 direct the fluid through the battery cells so that the fluid does not continue to pass from cell to cell but passes over different cells so that the cells experience the air at about the same temperature.

[0035] Also, the battery housing may include baffles 75, 76, 77, 78 like those described above.

[0036] Further, an auxiliary fan could be positioned in the tool housing itself as illustrated in phantom in Figure 1 to move fluid through the battery housing. Temperature sensors may be positioned in the housing to monitor individual battery cell temperature. Also, the baffles may be designed to direct fluid flow to the hottest battery cells. Thus, the cells would be cooled as well as the temperature being equalized.

[0037] Turning to Figures 4A and 4B, an additional embodiment of the present invention is illustrated. Here, the battery pack includes a housing 80, a plurality of cells 36 which are wrapped in a thermally conductive but electrically insulating substance 83 to remove heat from the battery pack. Also, a heat sink 84 is positioned between the cells for wicking the heat from the battery cells 36. Projecting portions 86 surround the batteries to effectively move heat towards the fins 88 of the heat sink 84. Also, a plurality of slots 90 are formed in the housing 80 to enable the heat to be removed from the battery cells 36. The heat sink 84 may be any type of metallic sink with the projecting portion 82 either being metallic or a thermally conductive medium, such as potting compound, gels or grease to extract the heat from the cells to the heat sink 84. The heat exits through the fins 88. Also, more fins, as well as larger projecting portions, surround battery cells which are known to have higher temperatures during charging of the battery as well as discharging when the tool is used.

[0038] Thus, heat is drawn from the battery cells 36 to the heat sink. The ventilation slots 90 enable fluid to pass over the fins 88 to remove heat. Also, an inlet 92 may be included in the housing to enable fluid to pass from a fan in the tool housing through the battery pack.

[0039] Figure 4C illustrates an additional embodiment of the present invention. The battery pack is similar to that in Figures 4A and 4B, except the housing 80' does not include the plurality of slots. The plurality of cells 36 are wrapped in a thermally conductive but electrically insulating substance such as tape 83 to enable heat to move from battery to battery via a heat sink 84. The heat sink 84 is positioned between the cells to wick heat from hotter battery cells and transfer the heat to battery cells having a lower temperature so that the temperatures of

the cells are equalized within the pack. Projecting portions 86 surround the battery cells to effectively remove heat towards the fins of the heat sink 84. Cells which are known to have higher temperatures are designated with 36'. Further, the heat sink may be a metallic type like that mentioned above, or may include thermally conductive mediums such as potting compound, gels or grease to extract heat from hotter cells and move it to the heat sink which, in turn, distributes the heat to the remaining cells such that the temperature within the cells is equalized. Thus, the temperature equalization of the cells enables the cells to be charged and discharged at a substantially equal rate which improves and increases the life of the battery pack.

[0040] Turning to Figure 5, an additional embodiment is illustrated. In Figure 5, the battery pack includes a housing 100 surrounding a plurality of cells 36. The housing 100 includes a plurality of slots 102 which act as outlets and an inlet 104. Also, a heat pump 106 is positioned within the housing 100. The heat pump 100 is a Peltier device, which is commonly known in the art. The Peltier device is coupled with heat sinks 108 and 110, As the Peltier device is activated, one heat sink becomes cold while the other becomes hot. If the current through the Peltier device is reversed, the cold and hot sides reverse. Thus, the heat sinks 108, 110 can be used to provide cool air into the battery housing 100 and enable the air to be baffled by baffles 112, 114, 116 and 118 to pass over the battery cells 36 and exit the housing through the outlet slots. Thus, cool air would be passed into the housing to cool the batteries. In the event that the battery cells are cold, the Peltier device current could be reversed wherein heated fluid would be passed through the battery pack to warm the battery cells so that they could be charged. The Peltier device is coupled to electronics 120 which may function off of the battery cells, a charger, or both, to control the cooling or heating. Also, a temperature sensor 122 may be positioned in the housing, with respect to the battery cells, so that heating and cooling may take place as desired.

[0041] Figure 6 is a view like that of Figure 5 including the heat pump 106. Additionally, a fan 124 is positioned within the housing to move the fluid through the battery pack 100. Here, fluid can be channeled throughout the battery enabling the battery to be cooled.

[0042] Turning to Figure 7, a battery pack is illustrated and designated with the reference numeral 130. Here, the battery pack is similar to that illustrated in Figure 4, however, a fan 132 is positioned within the battery pack. The fan 132 moves fluid across the fins 88 in an attempt to expel the heat from the battery pack housing 130.

[0043] Turning to Figure 8, an auxiliary fan module is illustrated and designated the reference numeral 140. The auxiliary fan module 140 includes a housing 142 which houses a fan 144. The housing includes an inlet 146 as well as an outlet 148. Fluid flows through the outlet 148, which is surrounded by seal 149, into the battery pack inlet 40 like that illustrated in Figures 1, 2. Electrical contacts 150 are positioned within the housing 142 to couple with the battery electrical contacts 29 to charge the battery cells 36. Further, electrical contacts 152 are secured with the housing 142 to mate with electrical contacts in a charger to run the fan during charging of the battery cells. Further, an electronic package 154 is within the housing 142 to control charging of the battery as well as operation of the fan 144. The electronic package 154 may be coupled with the temperature sensor to operate the fan as needed.

[0044] Turning to Figure 9, a perspective view of a battery charger is illustrated and designated with the reference numeral 160. The charger 160 includes contacts 162 to couple with a battery pack or auxiliary fan module to charge a battery pack. The charger 160 includes a base 164 which includes the electrical contacts coupled with the base. Further a vent system 166, with inlet 167 and outlet 169, is coupled with the base 164 to enable air to pass into and through the battery charger and in turn the battery pack. Further, the battery charger includes an electronics package 168 which receives the current from an AC source and converts it into the DC source required to charge the battery pack.

[0045] The charger 160 may be utilized with the disclosed battery packs with or without fans in the battery pack. In the event a battery pack is used which does not include a fan, convection would be used to enable air flow through the vent system 160 and in turn through the battery pack. In a situation where the battery pack includes a fan, the contacts 162 would also couple with the fan electronics within the battery pack to for operating the fan. In this event, the electronics in the charger would electrically couple with the fan electronics to turn on and turn off the fan when needed.

[0046] Also, the charger could be utilized with the auxiliary fan module 140 as illustrated in Figure 10. Here, the auxiliary fan module 140 is coupled with the electrical contacts 162 in the charger 160 to operate the fan 144 within the auxiliary fan module 140. Accordingly, the fan 144 may be turned on and off as desired.

[0047] Turning to Figure 11, a charger 180 is shown. The charger 180 is similar to the battery charger 160 except that the battery charger 180 includes a fan 182 coupled with the venting system 166. The fan 182 moves fluid through an inlet 184 and forces the fluid through an outlet 186 into the battery pack. In this type of charger 180, the fan 182 would be activated as desired. Further, the charger electronics could be coupled with a sensor inside of the battery pack which would be activated through the electrical contacts 162. The sensor would sense the temperature within the battery pack so that the fan could run intermittently. Also, the sensors may be removed and the fan would just run constantly while the charger is operating.

[0048] Turning to Figure 12, an auxiliary fan module is illustrated like that in Figure 8. Here, the auxiliary fan module 190 includes a fan 192, an inlet 194 and an outlet 196 in the housing 198. Also, a heat pump 200 as

described above is positioned within the housing 198. The heat pump would produce a cold heat sink 202 which would enable fluid to move in to the housing, via the fan, and pass over the cold heat sink and into the battery pack. The fluid would also pass over the hot side of the heat sink 206, withdrawing heat from the housing, and exhausting the air to ambient through outlet 208. In the event the battery pack is cold, the heat pump 200 may be reversed and heat may be passed into the battery pack to warm the battery pack before charging. The fan module 190 also includes electrical contacts 210 to couple with the battery pack. Also, electrical contacts 212 couple with the charger 160. The electronics 214 within the auxiliary fan module 190 couple with the charger and operate the fan to move fluid into the battery pack as desired.

[0049] Turning to Figures 13-15, additional embodiments of the present invention are shown. Figure 13 illustrates a perspective view of a battery cooler/heater device. Here, the battery cooler/heater 220 includes a housing 222. The housing 222 includes a battery receiving portion 224. The battery receiving portion 224 may be a cutout or the like in the battery housing 222 forming a depression to receive a battery housing pack. Further, the housing includes an inlet 226 and an outlet 228. The inlet enables fluid to pass into a duct in the housing 222 while the outlet enables the fluid to be passed out of the housing duct and into a battery pack. The inlet 226 is generally covered by a filter 230 and a grill 232 is attached to the housing 222 sandwiching the filter between the inlet and the grill 232. The grill 232 has slots 234 to enable air to pass through the grill into the filter and turn through the inlet 226.

[0050] An O-ring or some type of seal 236 is positioned around the outlet 228 as shown in Figure 14. The seal 236 mates with the battery pack to prohibit fluid from escaping around the battery pack housing while fluid is passed into the battery pack housing.

[0051] In Figure 14, the housing 222 includes a fan 240 to move fluid between the inlet 226 and outlet 228. The fan 240 is energized and de-energized by a switch 242. In Figure 14, the switch 242 is a manual switch enabling the user to manually turn on and turn off the fan 240 as desired. Also, a power cord 244 is coupled with the fan and switch electronics 246 to provide power to the battery cooler/heater 220.

[0052] Additionally, a Peltier device 250 (illustrated in phantom) may be positioned near the inlet which may provide cooled or heated fluid which is drawn into the battery pack as described above. The Peltier device 250 would be coupled with the electronics 246 so that the Peltier device 250 may deliver cold or hot fluid flow, depending upon if cooling or heating is desired, to the battery cells.

[0053] Turning to Figure 15, an additional embodiment of the battery heater/cooler 220 is shown. Here, the battery cooler is like that described above, except that an automatic switch 260 has replaced the manual switch 242. Here, as the battery pack housing is slid into the battery cooler/heater housing, the battery contacts the normally open switch 260 energizing the fan 240. As the battery pack housing is withdrawn from the battery cooler/heater, the switch 260 would return to its normally open position, de-energizing the fan.

[0054] As will be appreciated by those skilled in the art, the present invention provides the art with a battery pack which dissipates heat within the battery pack during charging of the cells as well as discharging of the cells while the battery pack is in use. Additionally, the invention provides auxiliary devices for aiding the changing of the battery pack temperature for optimizing charging of the pack. In accordance with the various aspects of the invention, the battery pack life can be increased, battery pack performance can be enhanced and charging time can be reduced.

[0055] While the above detailed description describes the preferred embodiment of the present invention, the invention is susceptible to modification, variation, and alteration without deviating from the scope and fair meaning of the subjoined claims.

Claims

1. A removable battery pack (26) comprising:
   a housing (34) with one or more cells (36) in said housing,
   characterized by:

   a vent system (38) in said housing for enabling fluid passage through said housing; and

   a mechanism (46, 48, 50, 52, 72, 76, 77, 84, 106, 108, 110, 132) associated with said battery pack (26) for dissipating heat in said battery pack housing.

2. A removable battery pack according to Claim 1, wherein said mechanism includes fluid directors (46, 48, 50, 52) for moving fluid to said one or more cells (36).

3. A removable battery pack according to claim 1 or claim 2, wherein said mechanism includes a heat sink (84, 108, 110) for dissipating heat from said one or more cells.

4. A removable battery pack according to any one of claims 1 to 3, wherein said mechanism includes a fan (72, 132), preferably in said battery pack housing (34) for forcing fluid through said vent system (38) to dissipate heat from the battery pack housing (34).

5. A removable battery pack according to any one of claims 1 to 4, further including a heat pump (100)

for providing cooling and heating of said one or more cells (36) in said battery pack housing (34)

6. A removable battery pack according to any one of claims 1 to 5, wherein said mechanism includes a sensor (120, 122) for sensing temperature of said one or more cells (36) and a heat dissipator (108, 110) for equalizing the temperature of said plurality of cells (36), said dissipator preferably wicking heat from hotter cells to ambient or to other cells (36) to equalize cell temperature.

7. A removable battery pack according to any one of claims 1 to 6, wherein said mechanism includes fluid directors (75, 76, 77, 90) for moving fluid around higher temperature cells of said one or more cells.

8. A removable battery pack (26) comprising:
a housing (34) with a plurality of cells (36) in said housing characterized by:
a mechanism (84, 100) in said housing coupled with said plurality of cells for equalizing temperature of said plurality of cells (36).

9. A removable battery pack according to claim 8, wherein said mechanism coupled with said cells includes a heat sink (84) for equalizing temperature of said cells in said housing, said heat sink preferably having an increased concentration (88) in the area having higher temperature cells, and/or preferably including a thermal conductive medium (86) surrounding said cells, a base, and fins (88).

10. A cordless power tool, which comprises a tool housing (22) including a mechanism for coupling (24) with a removable battery pack, and a removable battery pack (26) according to any one of claims 1 to 9.

11. A tool as claimed in claim 10, wherein said fan (72) is in said tool housing (22).

12. A tool according to claim 10 or claim 11, which includes a battery charger (140, 160, 180, 190, 220) for charging said battery pack (26), said battery charger (140, 160, 180, 190, 220) having a mechanism for moving fluid (144, 166, 182, 192, 240) through said vent system (38) of said battery pack housing (34).

13. A tool according to claim 12, wherein said charger (140, 160, 180, 190, 220) includes a fan (144, 192, 240) for forcing fluid through said vent system.

14. A tool according to Claim 12 or claim 13, wherein said battery pack housing (34) has a fan (72, 124, 132) and said charger has a vent system enabling fluid to be passed through said battery pack vent system.

15. A tool according to claim 12 or claim 13, wherein said charger (140, 160, 180, 190, 220) includes a vent system (148, 166, 196, 228) and an auxiliary fan (144, 124, 72) is coupled with said charger or battery pack housing for moving fluid through said battery pack housing.

16. A battery charger comprising:

a housing (160);

a mechanism for electrically coupling (162) with a chargeable battery pack that has a housing;

a power source coupled with said mechanism (244);

characterized by:
a mechanism in the housing for moving fluid (144, 166, 182, 192, 240) through a vent system of said battery pack.

17. A battery charger according to claim 16, wherein said charger (140, 160, 180, 190, 220) includes a fan (144, 192, 240) for forcing fluid through said vent system, and/or a vent system (148, 166, 196, 228) and an auxiliary fan (144, 124, 72) is coupled with said charger or battery pack housing for moving fluid through said battery pack housing.

18. An auxiliary fluid mover (140) for cooling a rechargeable battery pack, comprising and characterized by:

a housing (142);

a mechanism for electrically coupling with a battery pack (150), said mechanism coupled with said housing;

a mechanism for electrically coupling with a charger (152), said mechanism coupled with said housing;

a vent system (146, 148) for directing fluid to a battery pack; and

a mechanism (144) for moving fluid through said housing into a battery pack (34).

19. An auxiliary fluid mover according to claim 18, further including a heat pump (100) for providing cooling and heating of said one or more cells (36) in said battery pack housing (34).

20. An auxiliary fluid mover according to claim 18 or

claim 19, wherein said mechanism includes a fan (144) for forcing fluid through said vent (146, 148) system to dissipate heat from the battery pack housing.

21. A battery pack temperature change mechanism comprising and characterized by:

a housing (160, 222, 166, 240);

a mechanism in the housing for moving fluid through a vent system of a battery pack; and

a power source (244) coupled with said fluid moving mechanism.

22. A battery pack temperature change mechanism according to claim 21, wherein said fluid moving mechanism includes a fan (240) for forcing fluid through said vent system, and/or a vent system (166) in said housing.

23. A battery pack temperature change mechanism according to claim 21 or claim 22, which includes a switch (242, 220), preferably a manually activated switch, for activating the fluid moving mechanism.

24. The battery pack temperature change mechanism according to claim 23, wherein said switch (260) is automatically activated when said battery pack is coupled with said housing.

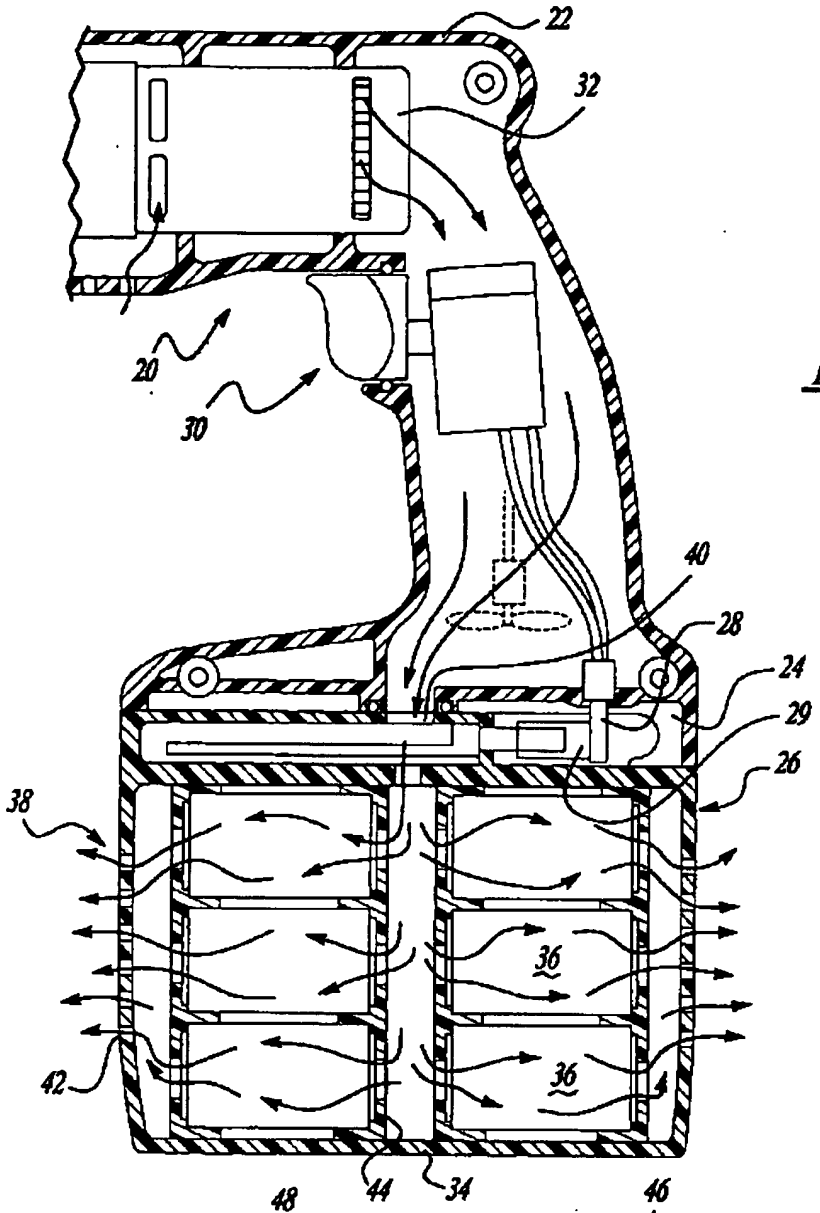
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Fig-1

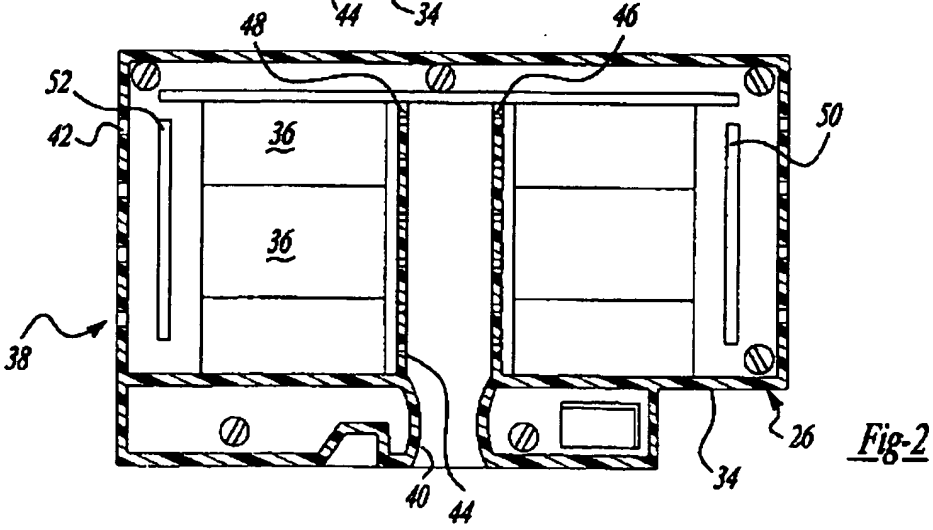
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Fig-2

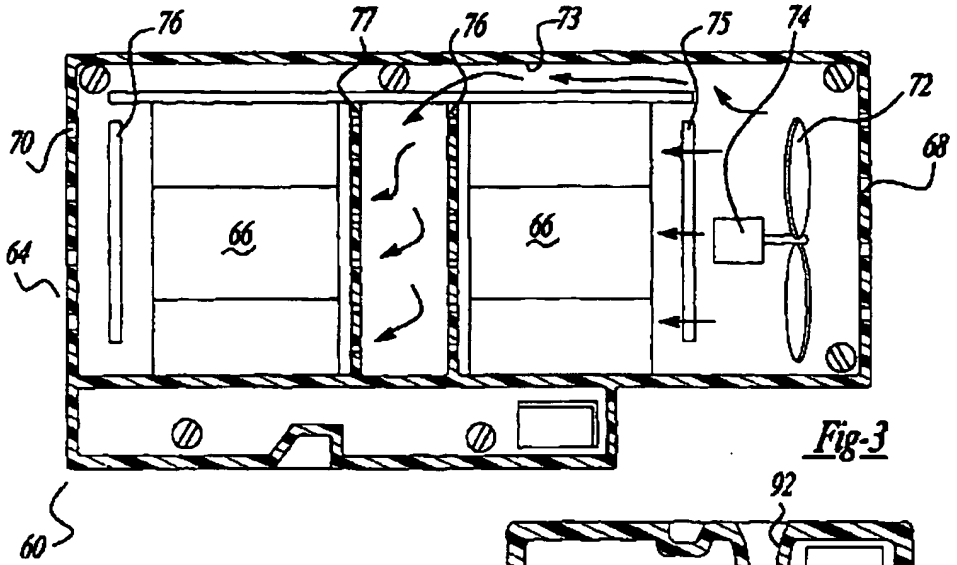

Fig-3

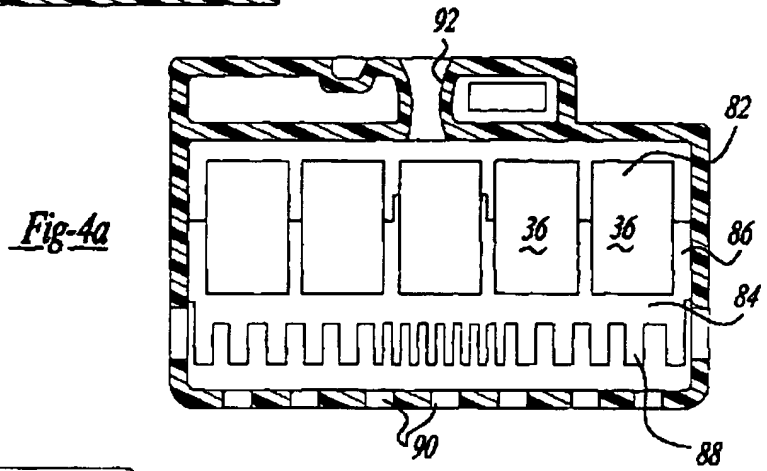

Fig-4a

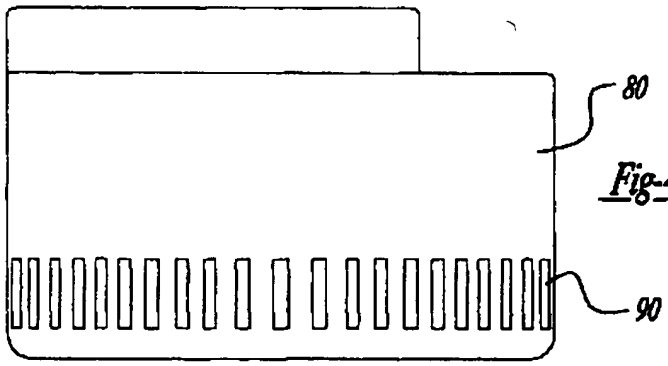

Fig-4b

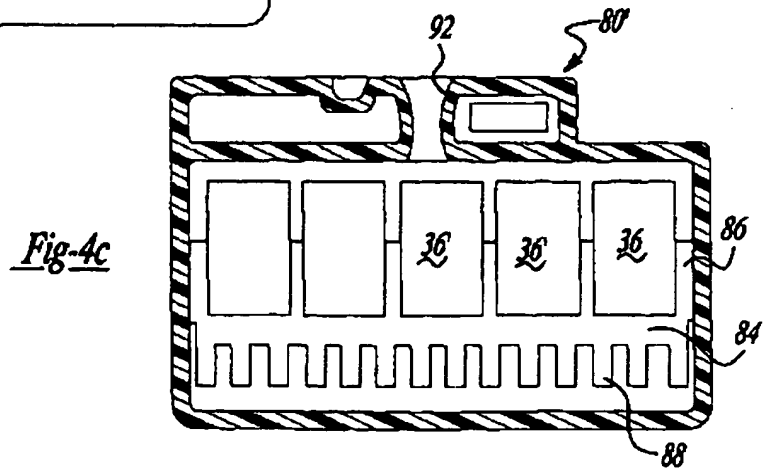

Fig-4c

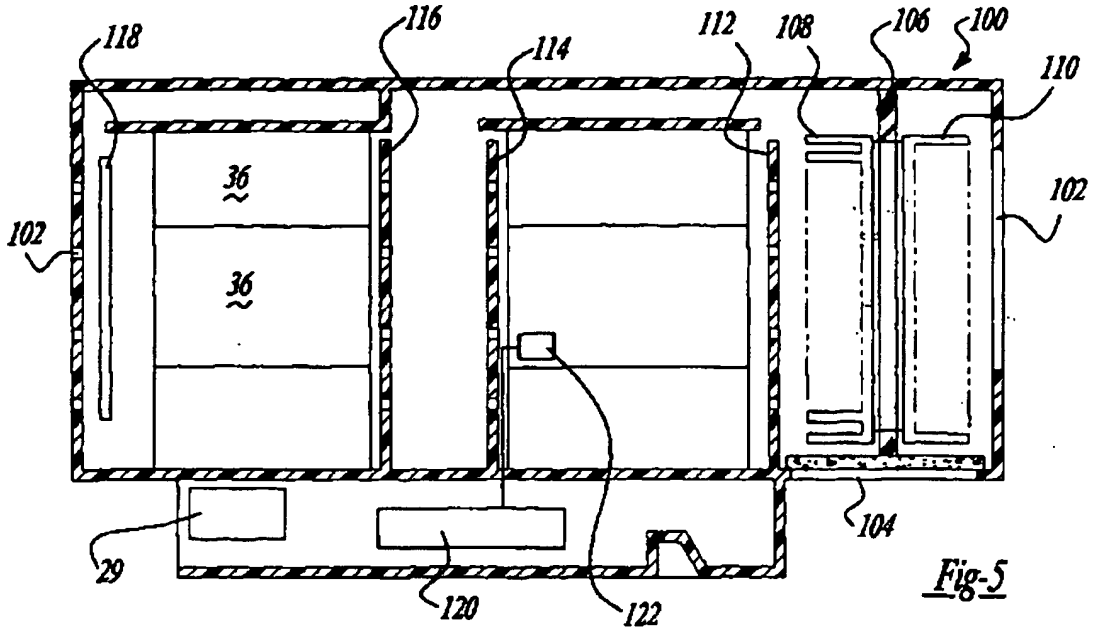

Fig-5

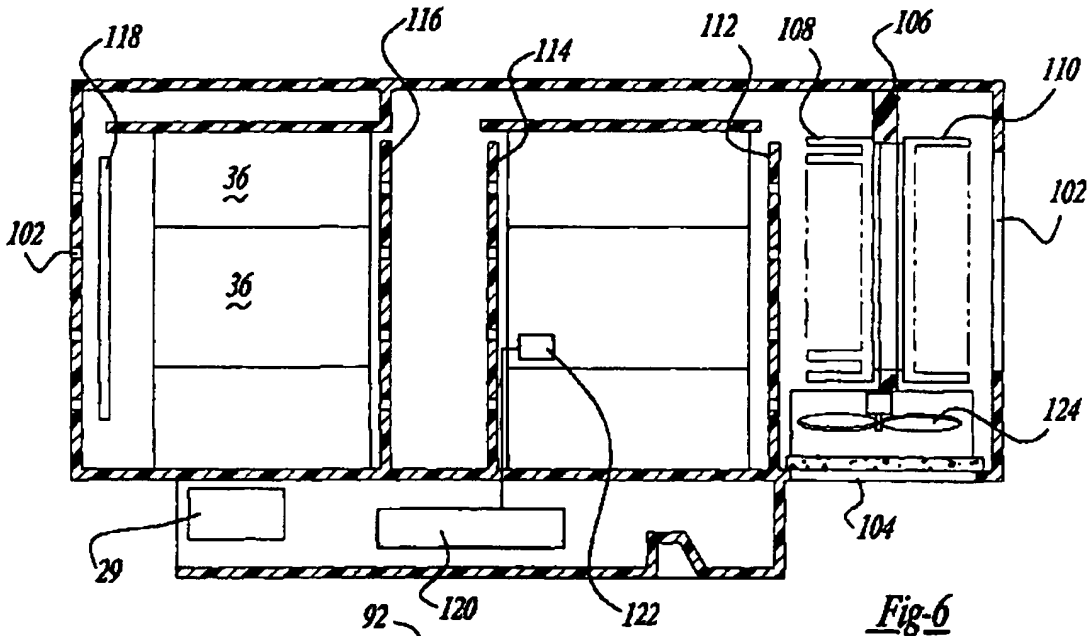

Fig-6

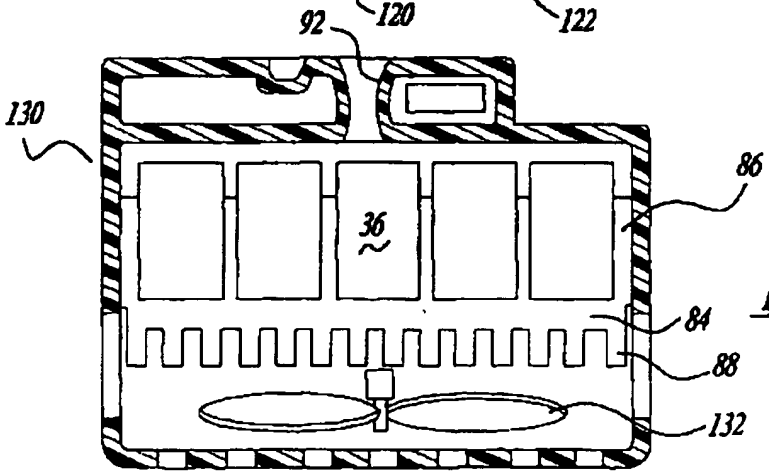

Fig-7

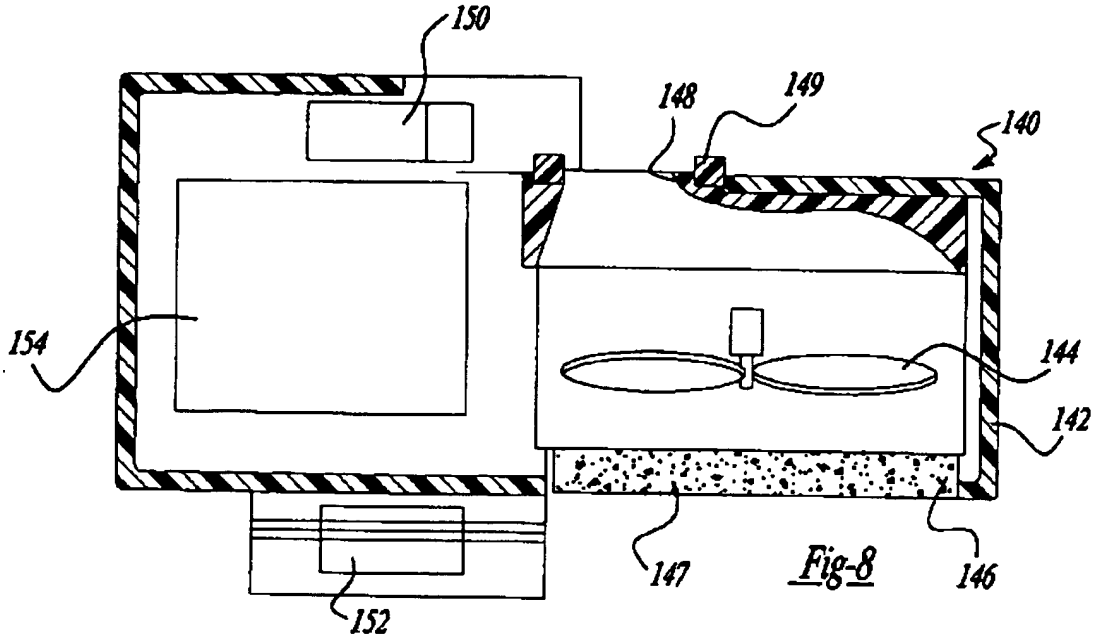

Fig-8

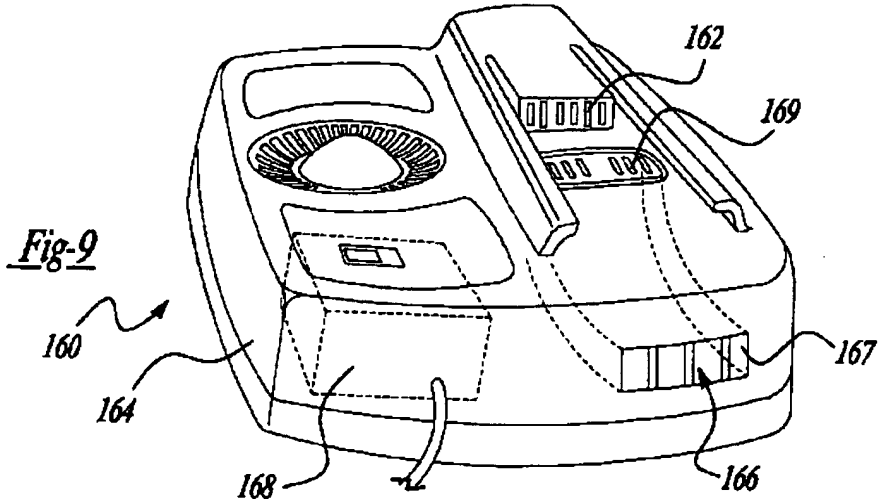

Fig-9

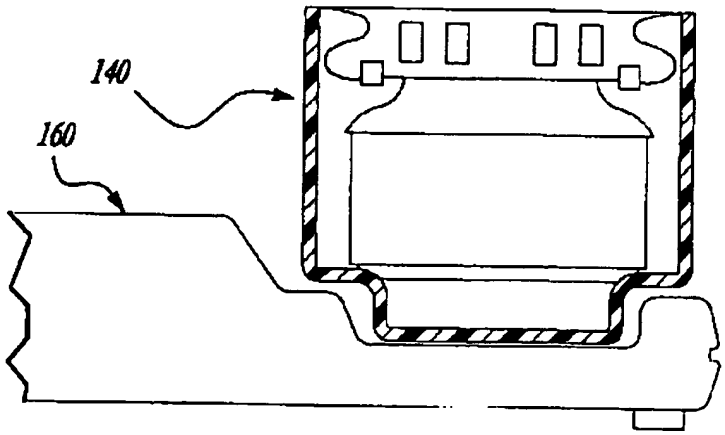

Fig-10

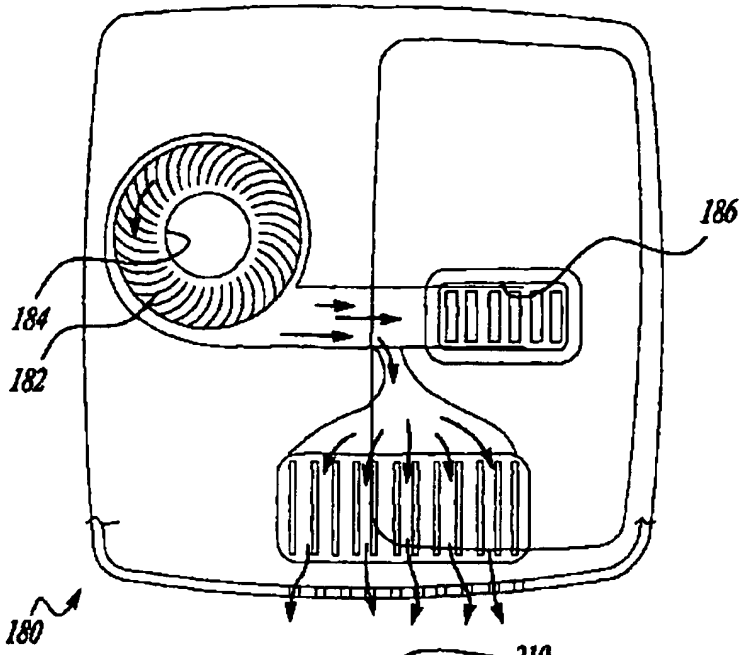

Fig-11

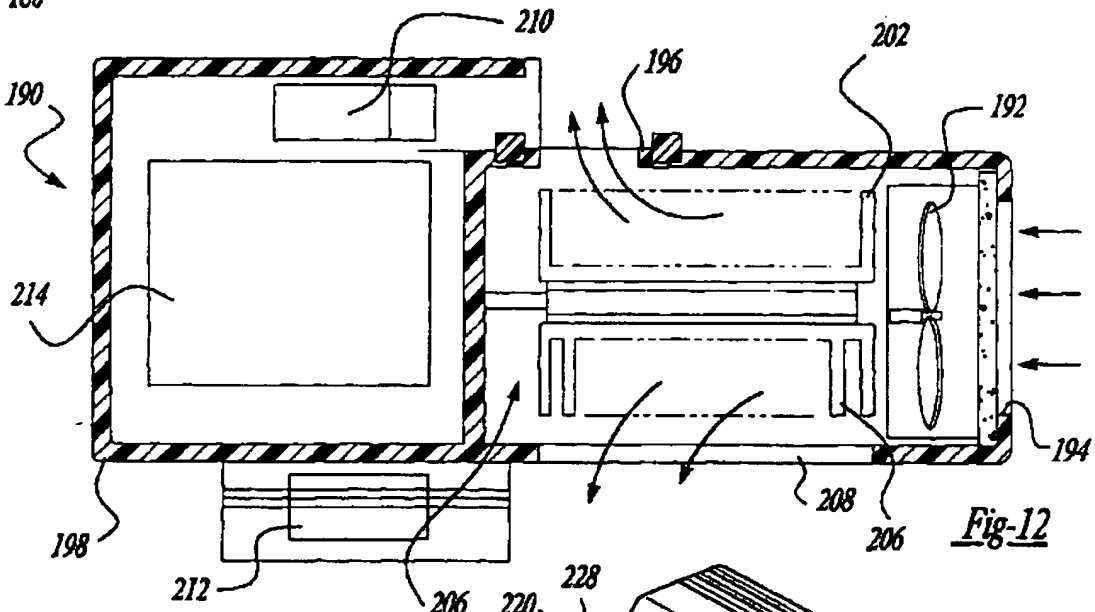

Fig-12

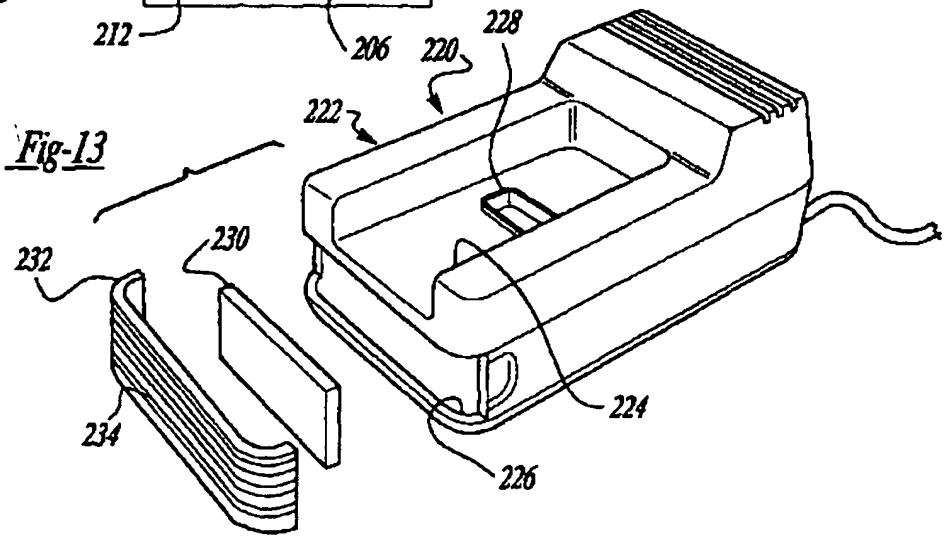

Fig-13

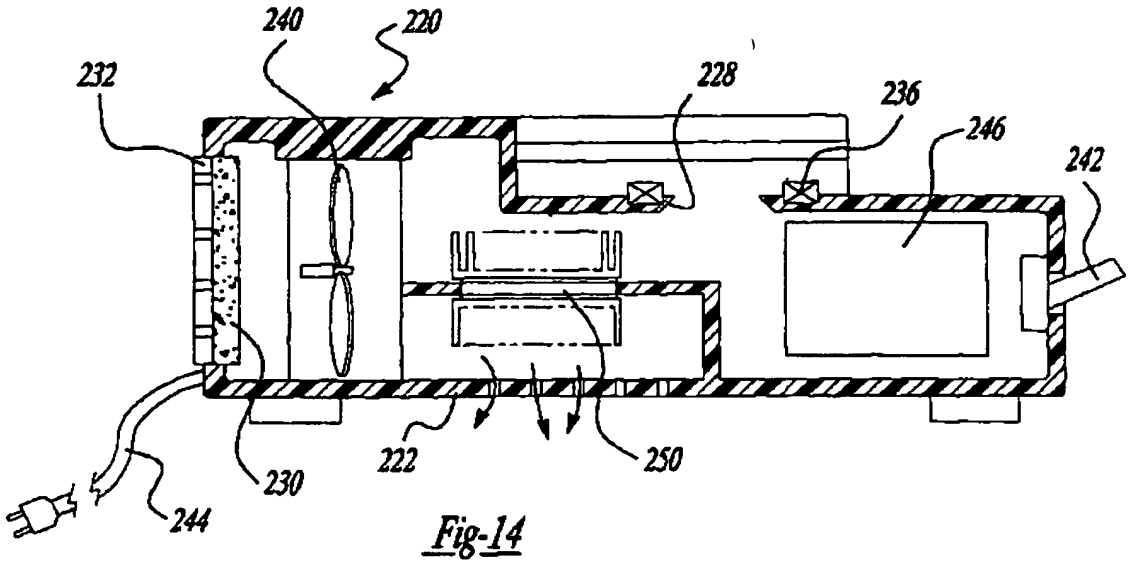
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Fig-14

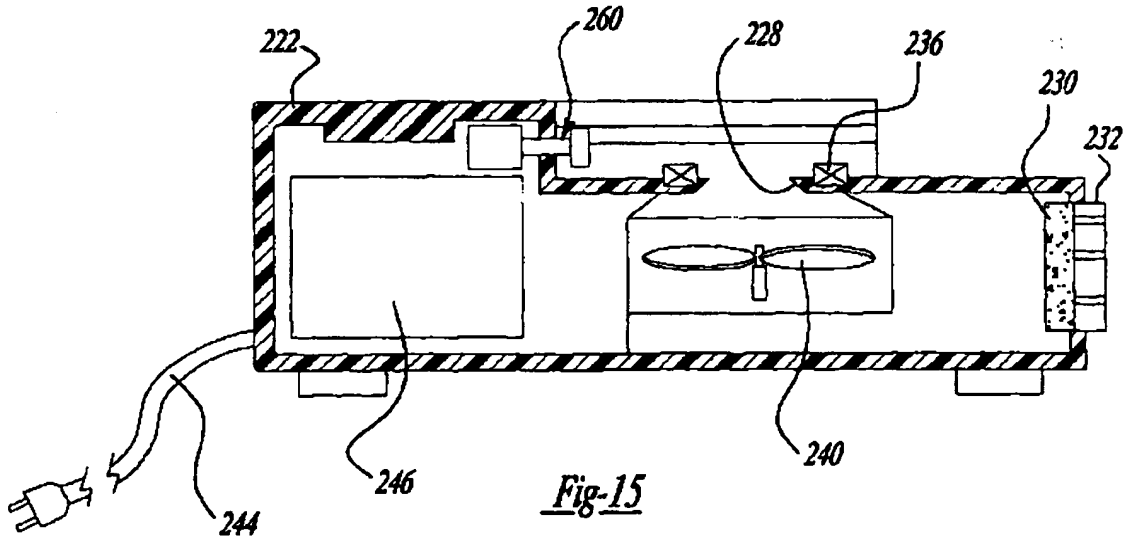
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Fig-15

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European Patent Office
Office européen des brevets

(11) EP 0 940 864 A3

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(54) Battery pack cooling system

(57) A cordless power tool (20) has a housing (22) which includes a mechanism (24) to couple with a removable battery pack (26). The battery pack (26) includes one or more battery cells (36) as well as a vent system (38) in the battery pack housing (34) which enables fluid to move through the housing (34). A mechanism (46, 48, 50, 52, 72, 76, 77, 84, 106, 108, 110, 132) is associated with the battery pack (26) to dissipate heat from the battery pack.

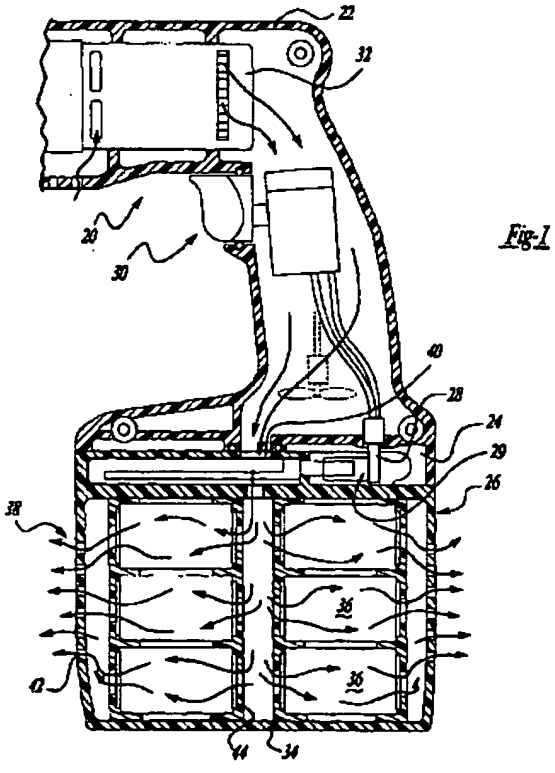

Fig.1

EP 0 940 864 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 1505

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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A		21,22	
X	DE 32 47 969 A (BBC BROWN BOVERI & CIE, MANNHEIM, DE) 28 June 1984 (1984-06-28) * page 7, line 29 - page 14, line 15 * * figures 1-3 *	1,2,7,8	
A		21	
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 02, 30 January 1998 (1998-01-30) & JP 09 259940 A (NISSAN MOTOR CO LTD), 3 October 1997 (1997-10-03) * abstract *	1,2,6-8, 21	
A	EP 0 593 869 A (WUERTH ADOLF GMBH & CO KG, KÜNZELSAU, DE) 27 April 1994 (1994-04-27) * column 3, line 48 - column 4, line 5 * * column 4, line 50 - column 5, line 24 * * figure 1 *	1,6,10, 13-16	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01M H02J
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A	WO 89 08345 A (BLACK & DECKER INC.,NEWARK, US) 8 September 1989 (1989-09-08) * page 5, line 1 - page 6, line 7 * * page 7, line 1 - line 16 * * figures 1,2,4 *	10,11,14	
A		23,24	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 December 1999	Peis, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 1505

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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E	EP 0 920 105 A (MATSUSHITA ELECTRIC WORKS LTD) 2 June 1999 (1999-06-02) * column 4, line 43 - column 8, line 3 * * figure 1 *	16	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 December 1999	Peis, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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T : theory or principle underlying the invention
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D : document cited in the application
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& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 30 1505

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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29-12-1999

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Office européen des brevets

(11) EP 0 940 864 B1

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(51) Int Cl.[7]: **H01M 2/10**, H01M 10/50, H02J 7/00

(21) Application number: **99301505.6**

(22) Date of filing: **01.03.1999**

(54) Battery pack cooling system

Kühlsystem für Batteriesatz

Système de refroidissement pour paquet de batteries

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **05.03.1998 US 35586**

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01116259.1 / 1 178 556
01116272.4 / 1 178 557
01123042.2 / 1 178 559

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- **Bradus, Robert**
  Bel Air, Maryland 21015 (US)
- **Kreiser, Douglas L.**
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- **PATENT ABSTRACTS OF JAPAN vol. 1998, no. 02, 30 January 1998 (1998-01-30) & JP 09 259940 A (NISSAN MOTOR CO LTD), 3 October 1997 (1997-10-03)**

EP 0 940 864 B1

Description

[0001] The present invention relates to battery cooling systems for cordless power tools.

[0002] Cordless products which use rechargeable batteries are prevalent throughout the workplace as well as in the home. From housewares to power tools, rechargeable batteries are used in numerous devices. Ordinarily, nickel-cadium or nickelmetal-hydride battery cells are used in these devices. Since the devices use a plurality of battery cells, the battery cells are ordinarily packaged as battery packs. These battery packs couple with the cordless devices and secure to the device. The battery pack may be removed from the cordless device and charged in a battery charger or charged in the cordless device itself.

[0003] As the cordless power device is used, current flows through the batteries to power the cordless device. As current is drawn off the batteries, heat is generated within the battery pack. Also, during charging of the battery pack, heat is likewise accumulated during the charging process. The heat created during discharge of the batteries as well as charging of the batteries which, in turn, leads to increased temperatures, may have a severe effect on the life expectancy and performance of the batteries. In order for batteries to properly charge, the batteries must be below a desired threshold temperature and the differential temperature between the cells in the battery pack should be minimised. Likewise, if the batteries become too hot during use, battery life will be cut short. Also, if a battery is below a certain threshold temperature, it will be too cold to charge and must be warmed before charging. Thus, it is desirous to maintain batteries within a desired temperature range for optimum performance as well as optimum charging.

[0004] Further, battery packs typically contain some battery cells close to the outer walls of the pack, while some battery cells are surrounded by other battery cells. Those cells close to the outer walls have better thermal conductivity to the outside ambient than do the cells that are surrounded by other cells. When a battery pack is discharging on the cordless device, the amount of heat generated is approximately the same in each cell. However, depending on the thermal path to ambient, different cells will reach different temperatures. Further, for the same reasons, different cells reach different temperatures during the charging process. Accordingly, if one cell is at an increased temperature with respect to the other cells, its charge or discharge efficiency will be different, and, therefore, it may charge or discharge faster than the other cells. This will lead to a decline in the performance of the entire pack.

[0005] It is known from EP 920 105 (which is relevant to the novelty of the present application insofar as the same Contracting States are designated) to provide a vent system in a battery pack for a cordless power tool through which an air flow is passed when the battery pack is charging, which air flow is generated by a fan in the battery charger. This provides cooling of the battery pack during charging but not during discharge of the battery pack.

[0006] It is also known from DE 43 27 391 and DE 40 29 018 to generate external air flows and to pass them through trays of batteries specifically used for vehicle propulsion in order to cool the batteries during use.

[0007] Finally, in DE 32 42 901 which relates to high temperature storage batteries which operate at 350°c and are used primarily for vehicle propulsion it is known to cool and equalise the temperature of cells in such batteries using a fluid heat exchanger.

[0008] In accordance with a first aspect of the invention, there is provided a removable battery pack for a cordless power tool having a housing with one or more cells in the housing, a vent system in the housing for enabling air to pass through the housing and a mechanism is associated with the battery pack to dissipate heat from the battery pack, characterised in that said mechanism includes a metallic heat sink to dissipate heat from the cells to the air in the housing. A fan may be used to force air through the vent system to dissipate heat from the battery pack. The fan may be either in the tool housing or in the battery pack.

[0009] In accordance with a second aspect of the invention, there is provided a removable battery pack which includes a housing with one or more cells in the housing and a metallic heat sink in the battery pack housing coupled with the plurality of cells to equalise temperature of the plurality of cells by thermal conduction of heat through the heat sink. The heat sink may include an increased concentration of material in areas having higher temperature cells. Also, the heat sink may include a thermally conductive electrically insulating medium surrounding the cells, a base, and fins. Also, the battery pack may include apertures for dissipating heat.

[0010] In accordance with a third aspect of the invention there is provided a cordless power tool which to reduce charging time comprises a housing including a mechanism to couple a removable battery pack and a removable battery pack as discussed above.

[0011] In accordance with a fourth aspect of the invention, a cordless power tool to reduce charging time comprises a housing including a mechanism to couple with a removable battery pack. A removable battery pack has a housing with one or more cells in the housing. A battery charger to charge the battery pack is also included. The battery charger has a mechanism to move air through the vent system of the battery pack housing. The charger may include a fan to force air the battery pack vent system. Further, the battery pack may include a fan and in this case the charger may include a vent system to enable air to pass by the cell or cells in the battery pack housing.

[0012] An auxiliary fan may be coupled with the charger or battery pack to force air through the charger or battery pack vent systems. The auxiliary fan is capable of

moving air through the battery pack while the battery pack is secured with the charger.

[0013] A heat pump may be included to provide heating or cooling of the battery cells depending upon the temperature of the battery cells. Thus, the heat pump enables the battery cells to be cooled if they are above a desired temperature and to be heated if the cells are below a desired temperature to enable charging of the cells.

[0014] A sensing mechanism may be included to sense the temperature of the plurality of cells in the battery pack housing. The heat dissipater equalises the temperature of the plurality of cells. The heat dissipater wicks heat from the hotter cells to ambient or to the other cells to equalise cell temperature within the housing.

[0015] In accordance with further aspects of the invention, several of the above features may be combined with one another to provide additional advantages. Additional objects and advantages of the invention will become apparent from the detailed description of the preferred embodiment, and the appended claims and accompanying drawings, or may be learned by practice of the invention.

[0016] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention and together with the description serve to explain the principles of the invention. In the drawings, the same reference numerals indicate the same parts.

[0017] Figure 1 is a partial cross-section view of a cordless power tool and battery in accordance with the present invention.

[0018] Figure 2 is a partial cross-section view of a battery pack in accordance with the present invention.

[0019] Figure 3 is a cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0020] Figure 4A is a cross-section view of another battery pack in accordance with the present invention.

[0021] Figure 4B is an elevation view of the battery pack of Figure 4A.

[0022] Figure 4C is a cross-section view of another battery pack in accordance with the present invention.

[0023] Figure 5 is another cross-section view of a battery pack in accordance with the present invention.

[0024] Figure 6 is an additional cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0025] Figure 7 is an additional cross-section view of a battery pack in accordance with the present invention.

[0026] Figure 8 is a cross-section view of an auxiliary fan module in accordance with the present invention.

[0027] Figure 9 is a perspective view of a charger in accordance with the present invention.

[0028] Figure 10 is a cross-section view of the auxiliary fan module coupled with the charger of Figure 9 in accordance with the present invention.

[0029] Figure 11 is a cross-section view of another embodiment of the present invention of a charger of Figure 9.

[0030] Figure 12 is a cross-section view like that of Figure 8 of another embodiment of an auxiliary fan in accordance with the present invention.

[0031] Figure 13 is a perspective view of a battery cooler/heater in accordance with the present invention.

[0032] Figure 14 is a longitudinal cross-section view of Figure 13.

[0033] Figure 15 is a view like Figure 14 of an additional embodiment of the battery cooler/heater.

[0034] Turning to the figures, a cordless device is illustrated and designated with the reference numeral 20. The cordless device ordinarily includes a clamshell type housing 22. The housing 22 includes a mechanism 24 to couple with a portion of a battery pack 26. The cordless device 20 includes electrical elements 28 which couple with the battery pack electrical elements 29. Also, the device includes a trigger 30 which energizes the motor 32 within the housing 22.

[0035] The battery pack 26 includes a housing 34 which contains a plurality of battery cells 36 within the housing 34. Also, the housing 34 includes a ventilation system 38 which enables fluid to pass through the housing 34 and move around the cells 36 to dissipate heat from the plurality of cells 36 to the ambient air. The venting system 38 ordinarily includes at least one inlet 40 and at least one outlet 42. The inlet and outlet are ordinarily apertures or slots in the housing 34. Also, a channel 44 is formed within the housing 26 and aligned with the inlet 40 to distribute the fluid flow around the battery cells 36 so that all of the battery cells 36 are cooled. Preferably, the fluid flows coaxially with respect to the axes of the batteries 36. Thus, as fluid enters into the channel 44, the fluid is directed over the battery cells and does not pass over one cell to the next cell, etc., but is passed over a number of cells at one time so that the fluid passing through the housing is not warmed by the first cell and then passed over the second cell. However, fluid could be passed over the battery cells transversely with respect to the battery cells axes.

[0036] Turning to Figure 2, an additional embodiment of a battery pack is shown. The battery pack 26 is like that illustrated in Figure 1, including the housing 34, ventilation system 38 with inlet 40 and outlet 42. Also, cells 36 are positioned within the housing. Additionally, the battery pack includes one or more baffles 46, 48, 50 and 52. The baffles direct the fluid to specific battery cells 36. Ordinarily, the fluid is passed into channel 44 and distributed through the baffles 46 and 48.

[0037] Turning to Figure 3, an additional embodiment of a battery pack is shown. Battery pack 60 includes a housing 62 with a venting system 64 which enables fluid to pass around the battery cells 66. The ventilation system 64 includes at least one inlet 68 and at least one outlet 70. Also, the battery housing includes a fan 72. The fan 72 may include a motor 74 which may run off of the battery cells 36. Also, the fan motor 74 may run off

of a charging circuit when the battery pack is in a charger. The fan 72 moves fluid through the battery pack inlet. The fluid is forced over the battery cells 66 and out the outlets 70. Thus, a positive pressure is created in the battery pack as fluid flows through the battery pack 60. However, a negative pressure could be created in the battery pack sucking fluid through the battery pack. The channels 73 direct the fluid through the battery cells so that the fluid does not continue to pass from cell to cell but passes over different cells so that the cells experience the air at about the same temperature.

[0038] Also, the battery housing may include baffles 75, 76, 77, 78 like those described above.

[0039] Further, an auxiliary fan could be positioned in the tool housing itself as illustrated in phantom in Figure 1 to move fluid through the battery housing. Temperature sensors may be positioned in the housing to monitor individual battery cell temperature. Also, the baffles may be designed to direct fluid flow to the hottest battery cells. Thus, the cells would be cooled as well as the temperature being equalized.

[0040] Turning to Figures 4A and 4B, an additional embodiment of the present invention is illustrated. Here, the battery pack includes a housing 80, a plurality of cells 36 which are wrapped in a thermally conductive but electrically insulating substance 83 to remove heat from the battery pack. Also, a heat sink 84 is positioned between the cells for wicking the heat from the battery cells 36. Projecting portions 86 surround the batteries to effectively move heat towards the fins 88 of the heat sink 84. Also, a plurality of slots 90 are formed in the housing 80 to enable the heat to be removed from the battery cells 36. The heat sink 84 may be any type of metallic sink with the projecting portion 82 either being metallic or a thermally conductive medium, such as potting compound, gels or grease to extract the heat from the cells to the heat sink 84. The heat exits through the fins 88. Also, more fins, as well as larger projecting portions, surround battery cells which are known to have higher temperatures during charging of the battery as well as discharging when the tool is used.

[0041] Thus, heat is drawn from the battery cells 36 to the heat sink. The ventilation slots 90 enable fluid to pass over the fins 88 to remove heat. Also, an inlet 92 may be included in the housing to enable fluid to pass from a fan in the tool housing through the battery pack.

[0042] Figure 4C illustrates an additional embodiment of the present invention. The battery pack is similar to that in Figures 4A and 4B, except the housing 80' does not include the plurality of slots. The plurality of cells 36 are wrapped in a thermally conductive but electrically insulating substance such as tape 83 to enable heat to move from battery to battery via a heat sink 84. The heat sink 84 is positioned between the cells to wick heat from hotter battery cells and transfer the heat to battery cells having a lower temperature so that the temperatures of the cells are equalized within the pack. Projecting portions 86 surround the battery cells to effectively remove heat towards the fins of the heat sink 84. Cells which are known to have higher temperatures are designated with 36'. Further, the heat sink may be a metallic type like that mentioned above, or may include thermally conductive mediums such as potting compound, gels or grease to extract heat from hotter cells and move it to the heat sink which, in turn, distributes the heat to the remaining cells such that the temperature within the cells is equalized. Thus, the temperature equalization of the cells enables the cells to be charged and discharged at a substantially equal rate which improves and increases the life of the battery pack.

[0043] Turning to Figure 5, an additional embodiment is illustrated. In Figure 5, the battery pack includes a housing 100 surrounding a plurality of cells 36. The housing 100 includes a plurality of slots 102 which act as outlets and an inlet 104. Also, a heat pump 106 is positioned within the housing 100. The heat pump 100 is a Peltier device, which is commonly known in the art. The Peltier device is coupled with heat sinks 108 and 110, As the Peltier device is activated, one heat sink becomes cold while the other becomes hot. If the current through the Peltier device is reversed, the cold and hot sides reverse. Thus, the heat sinks 108, 110 can be used to provide cool air into the battery housing 100 and enable the air to be baffled by baffles 112, 114, 116 and 118 to pass over the battery cells 36 and exit the housing through the outlet slots. Thus, cool air would be passed into the housing to cool the batteries. In the event that the battery cells are cold, the Peltier device current could be reversed wherein heated fluid would be passed through the battery pack to warm the battery cells so that they could be charged. The Peltier device is coupled to electronics 120 which may function off of the battery cells, a charger, or both, to control the cooling or heating. Also, a temperature sensor 122 may be positioned in the housing, with respect to the battery cells, so that heating and cooling may take place as desired.

[0044] Figure 6 is a view like that of Figure 5 including the heat pump 106. Additionally, a fan 124 is positioned within the housing to move the fluid through the battery pack 100. Here, fluid can be channeled throughout the battery enabling the battery to be cooled.

[0045] Turning to Figure 7, a battery pack is illustrated and designated with the reference numeral 130. Here, the battery pack is similar to that illustrated in Figure 4, however, a fan 132 is positioned within the battery pack. The fan 132 moves fluid across the fins 88 in an attempt to expel the heat from the battery pack housing 130.

[0046] Turning to Figure 8, an auxiliary fan module is illustrated and designated the reference numeral 140. The auxiliary fan module 140 includes a housing 142 which houses a fan 144. The housing includes an inlet 146 as well as an outlet 148. Fluid flows through the outlet 148, which is surrounded by seal 149, into the battery pack inlet 40 like that illustrated in Figures 1, 2. Electrical contacts 150 are positioned within the housing 142 to couple with the battery electrical contacts 29 to charge

the battery cells 36. Further, electrical contacts 152 are secured with the housing 142 to mate with electrical contacts in a charger to run the fan during charging of the battery cells. Further, an electronic package 154 is within the housing 142 to control charging of the battery as well as operation of the fan 144. The electronic package 154 may be coupled with the temperature sensor to operate the fan as needed.

[0047] Turning to Figure 9, a perspective view of a battery charger is illustrated and designated with the reference numeral 160. The charger 160 includes contacts 162 to couple with a battery pack or auxiliary fan module to charge a battery pack. The charger 160 includes a base 164 which includes the electrical contacts coupled with the base. Further a vent system 166, with inlet 167 and outlet 169, is coupled with the base 164 to enable air to pass into and through the battery charger and in turn the battery pack. Further, the battery charger includes an electronics package 168 which receives the current from an AC source and converts it into the DC source required to charge the battery pack.

[0048] The charger 160 may be utilized with the disclosed battery packs with or without fans in the battery pack. In the event a battery pack is used which does not include a fan, convection would be used to enable air flow through the vent system 160 and in turn through the battery pack. In a situation where the battery pack includes a fan, the contacts 162 would also couple with the fan electronics within the battery pack to for operating the fan. In this event, the electronics in the charger would electrically couple with the fan electronics to turn on and turn off the fan when needed.

[0049] Also, the charger could be utilized with the auxiliary fan module 140 as illustrated in Figure 10. Here, the auxiliary fan module 140 is coupled with the electrical contacts 162 in the charger 160 to operate the fan 144 within the auxiliary fan module 140. Accordingly, the fan 144 may be turned on and off as desired.

[0050] Turning to Figure 11, a charger 180 is shown. The charger 180 is similar to the battery charger 160 except that the battery charger 180 includes a fan 182 coupled with the venting system 166. The fan 182 moves fluid through an inlet 184 and forces the fluid through an outlet 186 into the battery pack. In this type of charger 180, the fan 182 would be activated as desired. Further, the charger electronics could be coupled with a sensor inside of the battery pack which would be activated through the electrical contacts 162. The sensor would sense the temperature within the battery pack so that the fan could run intermittently. Also, the sensors may be removed and the fan would just run constantly while the charger is operating.

[0051] Turning to Figure 12, an auxiliary fan module is illustrated like that in Figure 8. Here, the auxiliary fan module 190 includes a fan 192, an inlet 194 and an outlet 196 in the housing 198. Also, a heat pump 200 as described above is positioned within the housing 198. The heat pump would produce a cold heat sink 202 which would enable fluid to move in to the housing, via the fan, and pass over the cold heat sink and into the battery pack. The fluid would also pass over the hot side of the heat sink 206, withdrawing heat from the housing, and exhausting the air to ambient through outlet 208. In the event the battery pack is cold, the heat pump 200 may be reversed and heat may be passed into the battery pack to warm the battery pack before charging. The fan module 190 also includes electrical contacts 210 to couple with the battery pack. Also, electrical contacts 212 couple with the charger 160. The electronics 214 within the auxiliary fan module 190 couple with the charger and operate the fan to move fluid into the battery pack as desired.

[0052] Turning to Figures 13-15, additional embodiments of the present invention are shown. Figure 13 illustrates a perspective view of a battery cooler/heater device. Here, the battery cooler/heater 220 includes a housing 222. The housing 222 includes a battery receiving portion 224. The battery receiving portion 224 may be a cutout or the like in the battery housing 222 forming a depression to receive a battery housing pack. Further, the housing includes an inlet 226 and an outlet 228. The inlet enables fluid to pass into a duct in the housing 222 while the outlet enables the fluid to be passed out of the housing duct and into a battery pack. The inlet 226 is generally covered by a filter 230 and a grill 232 is attached to the housing 222 sandwiching the filter between the inlet and the grill 232. The grill 232 has slots 234 to enable air to pass through the grill into the filter and turn through the inlet 226.

[0053] An O-ring or some type of seal 236 is positioned around the outlet 228 as shown in Figure 14. The seal 236 mates with the battery pack to prohibit fluid from escaping around the battery pack housing while fluid is passed into the battery pack housing.

[0054] In Figure 14, the housing 222 includes a fan 240 to move fluid between the inlet 226 and outlet 228. The fan 240 is energized and de-energized by a switch 242. In Figure 14, the switch 242 is a manual switch enabling the user to manually turn on and turn off the fan 240 as desired. Also, a power cord 244 is coupled with the fan and switch electronics 246 to provide power to the battery cooler/heater 220.

[0055] Additionally, a Peltier device 250 (illustrated in phantom) may be positioned near the inlet which may provide cooled or heated fluid which is drawn into the battery pack as described above. The Peltier device 250 would be coupled with the electronics 246 so that the Peltier device 250 may deliver cold or hot fluid flow, depending upon if cooling or heating is desired, to the battery cells.

[0056] Turning to Figure 15, an additional embodiment of the battery heater/cooler 220 is shown. Here, the battery cooler is like that described above, except that an automatic switch 260 has replaced the manual switch 242. Here, as the battery pack housing is slid into the battery cooler/heater housing, the battery contacts

the normally open switch 260 energizing the fan 240. As the battery pack housing is withdrawn from the battery cooler/heater, the switch 260 would return to its normally open position, de-energizing the fan.

[0057] As will be appreciated by those skilled in the art, the present invention provides the art with a battery pack which dissipates heat within the battery pack during charging of the cells as well as discharging of the cells while the battery pack is in use. Additionally, the invention provides auxiliary devices for aiding the changing of the battery pack temperature for optimizing charging of the pack. In accordance with the various aspects of the invention, the battery pack life can be increased, battery pack performance can be enhanced and charging time can be reduced.

[0058] While the above detailed description describes the preferred embodiment of the present invention, the invention is susceptible to modification, variation, and alteration without deviating from the scope and fair meaning of the subjoined claims.

Claims

1. A removable battery pack (26) for a cordless power tool comprising:

   a housing (34) with one or more cells (36) in said housing;

   a vent system (38) in said housing for enabling air passage through said housing; and

   a mechanism associated with said battery pack (26) for dissipating heat in said battery pack housing, **characterised in that** said mechanism includes a metallic heat sink (84) for dissipating heat from said one or more cells to the air in said housing.

2. A removable battery pack according to Claim 1, wherein said mechanism additionally includes fluid directors (46, 48, 50, 52) for moving air to said one or more cells (36).

3. A removable battery pack according to claim 1 or claim 2, wherein said mechanism includes a fan (72, 132) for forcing air through said vent system (38) to dissipate heat from the battery pack housing (34).

4. A removable battery pack according to claim 3 wherein the fan (72, 132) is located in said battery pack housing (34).

5. A removable battery pack according to anyone of claims 1 to 4, further including a heat pump (100) for providing cooling and heating of said one or more cells (36) in said battery pack housing (34).

6. A removable battery pack according to anyone of claims 1 to 5, wherein said mechanism includes a sensor (120, 122) for sensing temperature of said one or more cells (36) and a heat dissipator (108, 110) for equalizing the temperature of said plurality of cells (36), said dissipator preferably wicking heat from hotter cells to ambient or to other cells (36) to equalize cell temperature.

7. A removable battery pack according to anyone of claims 1 to 6, wherein said mechanism includes fluid directors (75, 76, 77, 90) for moving air around higher temperature cells of said one or more cells.

8. A removable battery pack according to claim 1, wherein said heat sink (84) has an increased concentration in the area having higher temperature cells.

9. A removable battery pack according to claim 1 or claim 8 including a thermally conductive medium (86) surrounding said cells, a base, and fins (88).

10. A removable battery pack (26) for a cordless power tool comprising:

    a housing (34) with a plurality of cells (36) in said housing; **characterised by:**

    a metallic heat sink (84) in said housing coupled with said plurality of cells for equalizing temperature of said plurality of cells (36) by the thermal conduction of heat through the heat sink.

11. A removable battery pack according to claim 10, wherein said heat sink has an increased concentration (88) in the area having higher temperature cells.

12. A removable battery pack according to claim 10 or claim 11 including a thermally conductive medium (86) surrounding said cells, a base, and fins (88).

13. A cordless power tool (20), which comprises a tool housing (22) including a mechanism for coupling (24) with a removable battery pack, and a removable battery pack (26) according to anyone of claims 1 to 12.

14. A tool as claimed in claim 13, wherein said fan (72) is in said tool housing (22).

15. A tool according to claim 12 or claim 13 which includes a battery charger (140, 160, 180, 190, 220) for charging said battery pack (26), said battery

charger (140, 160, 180, 190, 220) having a mechanism for moving air (144, 166, 182, 192, 240) through said vent system (38) of said battery pack housing (34).

16. A tool according to claim 15, wherein said charger (140, 160, 180, 190, 220) includes a fan (144, 192, 240) for forcing air through said vent system.

17. A tool according to Claim 15 or claim 16, wherein said battery pack housing (34) has a fan (72, 124, 132) and said charger has a vent system enabling air to be passed through said battery pack vent system.

18. A tool according to claim 15 or claim 16, wherein said charger (140,160, 180, 190, 220) includes a vent system (148, 166, 196, 228) and an auxiliary fan (144, 124, 72) is coupled with-said charger or battery pack housing for moving air through said battery pack housing.

Patentansprüche

1. Abnehmbarer Batteriesatz (26) für ein kabelloses Motorwerkzeug, mit:

   einem Gehäuse (34) mit einer oder mehreren Zellen (36) in dem Gehäuse;
   einem Belüftungssystem (38) in dem Gehäuse, um einen Luftdurchgang durch das Gehäuse zu ermöglichen; und
   einem Mechanismus, der mit dem Batteriesatz (26) in Beziehung steht, um Wärme in dem Batteriesatz-Gehäuse zu verteilen, **dadurch gekennzeichnet, daß** der Mechanismus eine metallische Wärmesenke (84) enthält, um Wärme von der einen oder den mehreren Zellen in die Luft in dem Gehäuse zu verteilen.

2. Abnehmbarer Batteriesatz nach Anspruch 1, bei dem der Mechanismus außerdem Fluid-Leitmittel (46, 48, 50, 52) aufweist, um Luft zu der einen oder zu den mehreren Zellen (36) zu leiten.

3. Abnehmbarer Batteriesatz nach Anspruch 1 oder Anspruch 2, bei dem der Mechanismus ein Gebläse (72, 132) aufweist, um Luft durch das Belüftungssystem (38) zu blasen, um Wärme aus , dem Batteriesatz-Gehäuse (34) zu verteilen.

4. Abnehmbarer Batteriesatz nach Anspruch 3, bei dem sich das Gebläse (72, 132) in dem Batteriesatz-Gehäuse (34) befindet.

5. Abnehmbarer Batteriesatz nach einem der Ansprüche 1 bis 4, außerdem mit einer Wärmepumpe (100), um das Abkühlen und Erwärmen von der einen oder den mehreren Zellen (36) in dem Batteriesatz-Gehäuse (34) zu bewirken.

6. Abnehmbarer Batteriesatz nach einem der Ansprüche 1 bis 5, bei dem der Mechanismus einen Sensor (120, 122) zum Erfassen der Temperatur von der einen oder den mehreren Zellen (36) und einen Wärme-Dissipator (108, 110) aufweist, um die Temperatur der Vielzahl von Zellen (36) auszugleichen, wobei der Dissipator vorzugsweise Wärme von heißeren Zellen in die Umgebung oder zu anderen Zellen (36) weiterleitet, um die Zellen-Temperatur auszugleichen.

7. Abnehmbarer Batteriesatz nach einem der Ansprüche 1 bis 6, bei dem der Mechanismus Fluid-Leitmittel (75, 76, 77, 90) aufweist, um Luft um Zellen mit einer höheren Temperatur von der einen oder den mehreren Zellen herum zu bewegen.

8. Abnehmbarer Batteriesatz nach Anspruch 1, bei dem die Wärmesenke (84) eine erhöhte Konzentration in dem Gebiet mit Zellen hat, die eine höhere Temperatur haben.

9. Abnehmbarer Batteriesatz nach Anspruch 1 oder Anspruch 8, mit einem thermisch leitfähigen Medium (86), das die Zellen, eine Basis und Rippen (88) umgibt.

10. Abnehmbarer Batteriesatz (26) für ein kabelloses Motorwerkzeug, mit:

    einem Gehäuse (34) mit einer Vielzahl von Zellen (36) in dem Gehäuse; **gekennzeichnet durch**:

    eine metallische Wärmesenke (84) in dem Gehäuse, die mit der Vielzahl von Zellen gekoppelt ist, um die Temperatur der Vielzahl von Zellen (36) **durch** thermische Konduktion von Wärme **durch** die Wärmesenke auszugleichen.

11. Abnehmbarer Batteriesatz nach Anspruch 10, bei dem die Wärmesenke eine erhöhte Konzentration (88) in dem Gebiet mit Zellen hat, die eine höhere Temperatur haben.

12. Abnehmbarer Batteriesatz nach Anspruch 10 oder Anspruch 11, mit einem thermisch leitfähigen Medium (86), das die Zellen, eine Basis und Rippen (88) umgibt.

13. Kabelloses Motorwerkzeug (20), das ein Werkzeug-Gehäuse (22) mit einem Mechanismus zur Kopplung (24) mit einem abnehmbaren Batterie-

satz und einen abnehmbaren Batteriesatz (26) gemäß einem der Ansprüche 1 bis 12 aufweist:

14. Werkzeug nach Anspruch 13, bei dem sich das Gebläse (72) in dem Werkzeug-Gehäuse (22) befindet.

15. Werkzeug nach Anspruch 12 oder Anspruch 13, mit einem Batterie-Ladegerät (140, 160, 180, 190, 220) zum Aufladen von dem Batteriesatz (26), wobei das Batterie-Ladegerät (140, 160, 180, 190, 220) einen Mechanismus aufweist, um Luft (144, 166, 182, 192, 240) durch das Belüftungssystem (38) von dem Batteriesatz-Gehäuses (34) zu bewegen.

16. Werkzeug nach Anspruch 15, bei dem das Ladegerät (140, 160, 180, 190, 220) ein Gebläse (144, 192, 240) aufweist, um Luft durch das Belüftungssystem zu blasen.

17. Werkzeug nach Anspruch 15 oder Anspruch 16, bei dem das Batteriesatz-Gehäuse (34) ein Gebläse (72, 124, 132) aufweist und das Ladegerät ein Belüftungssystem hat, um zu ermöglichen, daß Luft durch das Batteriesatz-Belüftungssystem geleitet wird.

18. Werkzeug nach Anspruch 15 oder Anspruch 16, bei dem das Ladegerät (140, 160, 180, 190, 220) ein Belüftungssystem (148, 166, 196, 228) aufweist und ein zusätzliches Gebläse (144, 124, 72) mit dem Ladegerät oder mit dem Batteriesatz-Gehäuse gekoppelt ist, um Luft durch das Batteriesatz-Gehäuse zu bewegen.

Revendications

1. Batterie amovible (26) pour outil électrique sans fil, comprenant :

   - une enveloppe (34) avec une ou plusieurs cellules (36) dans celle-ci ;
   - un système de ventilation (38) dans ladite enveloppe pour permettre le passage d'air à travers ladite enveloppe ; et
   - un mécanisme associé à ladite batterie (26) pour dissiper la chaleur dans ladite enveloppe de batterie, **caractérisée en ce que** ledit mécanisme comprend un dissipateur thermique métallique (84) pour dissiper la chaleur provenant d'une ou plusieurs cellules vers l'air dans ladite enveloppe.

2. Batterie amovible selon la revendication 1, dans laquelle ledit mécanisme comprend en outre des déflecteurs de fluide (46, 48, 50, 52) pour diriger l'air vers lesdites une ou plusieurs cellules (36).

3. Batterie amovible selon la revendication 1 ou la revendication 2, dans laquelle ledit mécanisme comprend un ventilateur (72, 132) pour forcer de l'air à travers ledit système de ventilation (38) afin de dissiper la chaleur provenant de l'enveloppe (34) de batterie.

4. Batterie amovible selon la revendication 3, dans laquelle le ventilateur (72, 132) est disposé dans ladite enveloppe de batterie (34).

5. Batterie amovible selon une quelconque des revendications 1 à 4, comprenant en outre une pompe à chaleur (100) pour assurer un refroidissement et un chauffage desdites une ou plusieurs cellules (36) dans ladite enveloppe de batterie (34).

6. Batterie amovible selon une quelconque des revendications 1 à 5, dans laquelle ledit mécanisme comprend un capteur (120, 122) pour détecter la température desdites une ou plusieurs cellules (36) et un dissipateur de chaleur (108, 110) pour égaliser la température de ladite pluralité de cellules (36), ledit dissipateur transférant de préférence la chaleur depuis les cellules les plus chaudes vers l'air ambiant ou vers d'autres cellules (36) afin d'égaliser la température de celles-ci.

7. Batterie amovible selon une quelconque des revendications 1 à 6, dans laquelle ledit mécanisme comprend des déflecteurs de fluide (75, 76, 77, 90) pour déplacer de l'air autour des cellules à température plus élevée desdites une ou plusieurs cellules.

8. Batterie amovible selon la revendication 1, dans laquelle ledit dissipateur thermique (84) présente une concentration accrue dans les régions ayant des cellules à température plus élevée.

9. Batterie amovible selon la revendication 1 ou la revendication 8, comprenant une substance thermiquement conductrice (86) entourant lesdites cellules, une base et des ailettes (88).

10. Batterie amovible (26) pour outil électrique sans fil, comprenant :

    - une enveloppe (34) avec une pluralité de cellules (36) dans ladite enveloppe ;
    - **caractérisée en ce qu'**elle comporte un dissipateur thermique métallique (84) dans ladite enveloppe, qui est couplé à ladite pluralité de cellules afin d'égaliser la température de ladite pluralité de cellules (36) par conduction thermique de chaleur à travers le dissipateur thermique.

11. Batterie amovible selon la revendication 10, dans

laquelle ledit dissipateur thermique présente une concentration supérieure (88) dans les régions ayant des cellules à température plus élevée.

12. Batterie amovible selon la revendication 10 ou la revendication 11, comprenant une substance thermiquement conductrice (86) entourant lesdites cellules, une base et des ailettes (88).

13. Outil électrique sans fil (20), qui comprend un logement d'outil (22) comportant un mécanisme pour se connecter (24) à une batterie amovible et une batterie amovible (26) selon une quelconque des revendications 1 à 12.

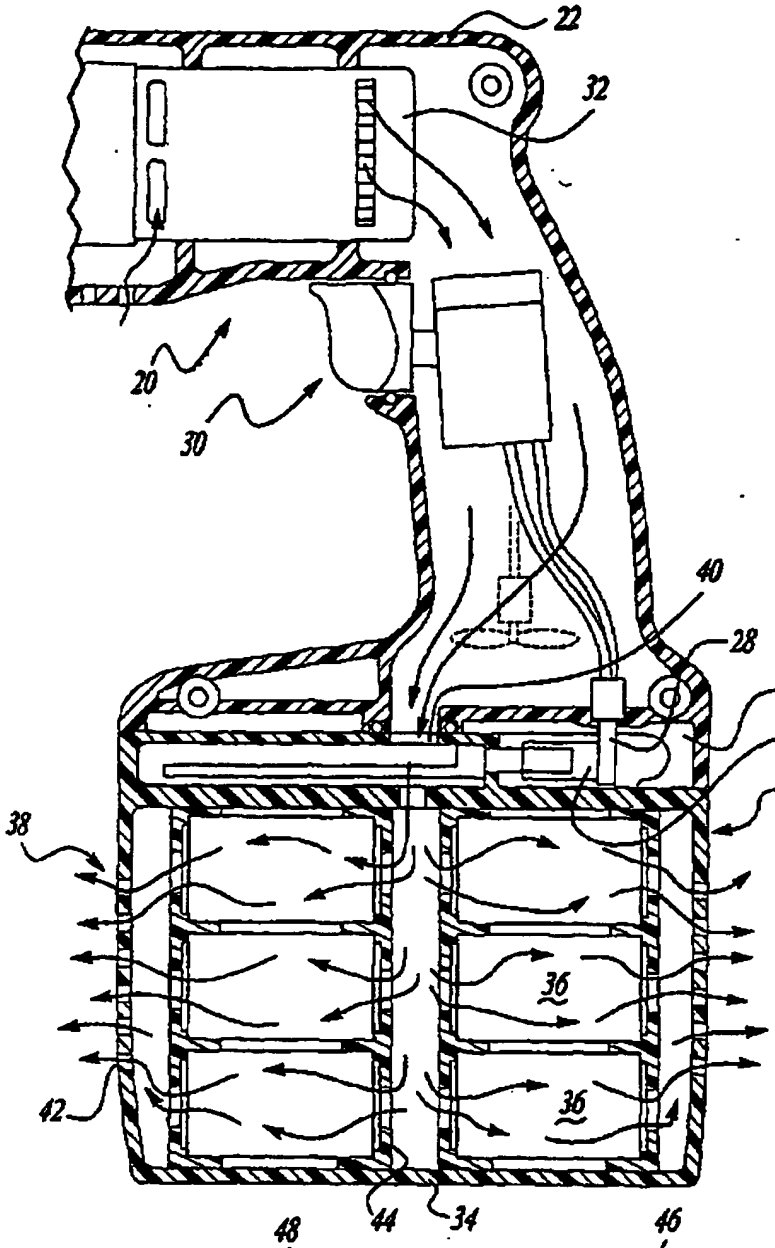
14. Outil selon la revendication 13, dans lequel ledit ventilateur (72) est disposé dans ledit logement d'outil (22).

15. Outil selon la revendication 12 ou la revendication 13, qui comprend un chargeur de batterie (140, 160, 180, 190, 220) pour charger ladite batterie (26), ledit chargeur de batterie (140, 160, 180, 190, 220) ayant un mécanisme pour déplacer de l'air (144, 166, 182, 192, 240) à travers ledit système de ventilation (38) de ladite enveloppe de batterie (34).

16. Outil selon la revendication 15, dans lequel ledit chargeur (140, 160, 180, 190, 220) comprend en ventilateur (144, 192, 240) pour forcer de l'air à travers ledit système de ventilation.

17. Outil selon la revendication 15 ou la revendication 16, dans lequel ladite enveloppe de batterie (34) possède un ventilateur (72, 124, 132) et ledit chargeur possède un système de ventilation permettant à de l'air d'être fait passer à travers ledit système de ventilation de ladite batterie.

18. Outil selon la revendication 15 ou la revendication 16, dans lequel ledit chargeur (140, 160, 180, 190, 220) comprend un système de ventilation (148, 166, 196, 228) et dans lequel un ventilateur auxiliaire (141, 124, 72) est couplé audit chargeur ou à l'enveloppe de la batterie pour déplacer de l'air à travers ladite enveloppe de la batterie.


22
32
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24
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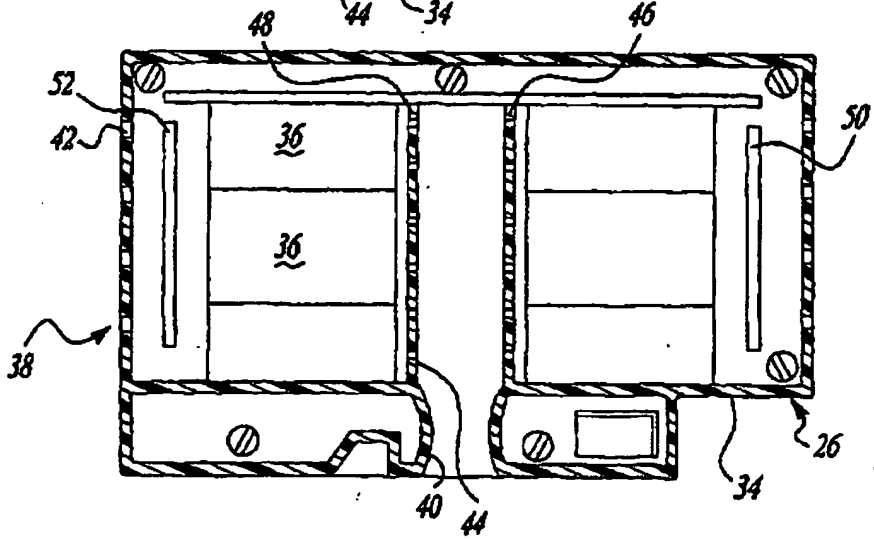
44
34

Fig-1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38
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44
34
26

Fig-2

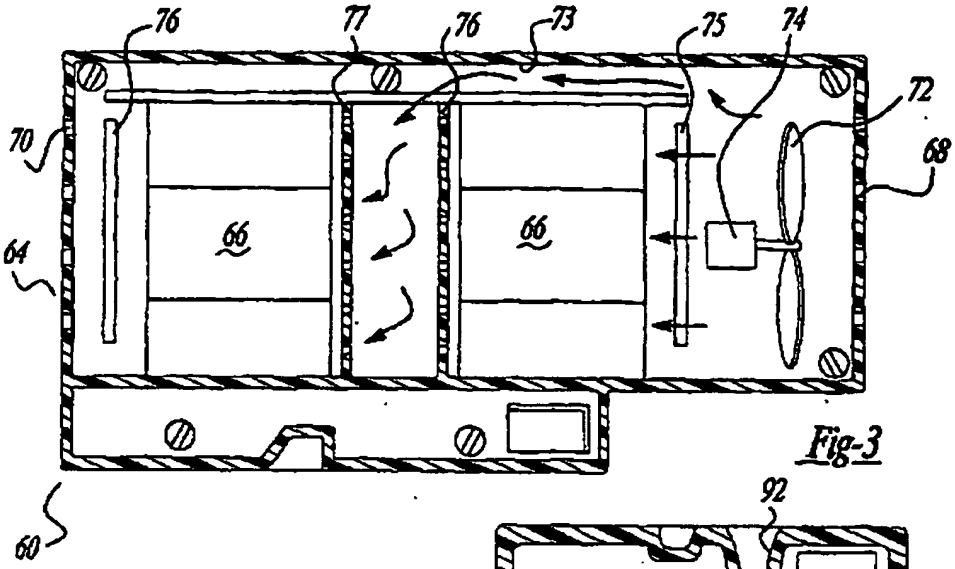


Fig-3

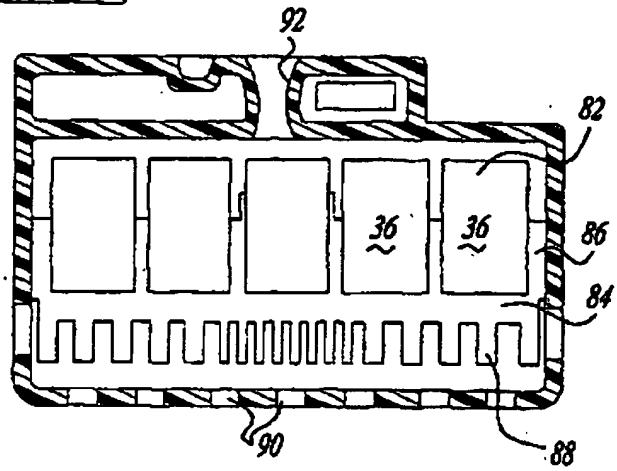


Fig-4a

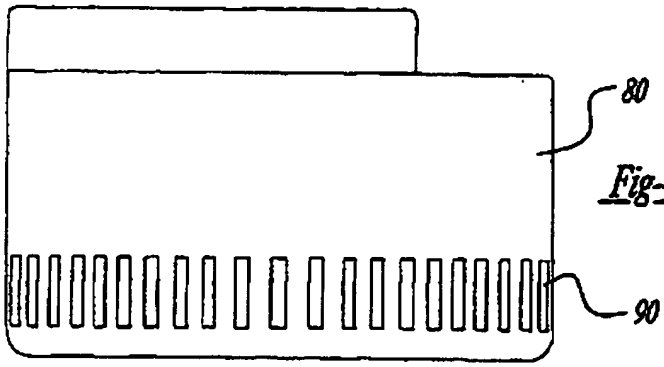


Fig-4b

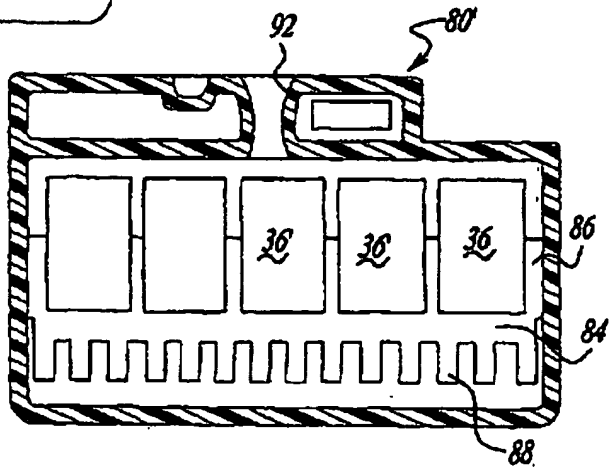


Fig-4c

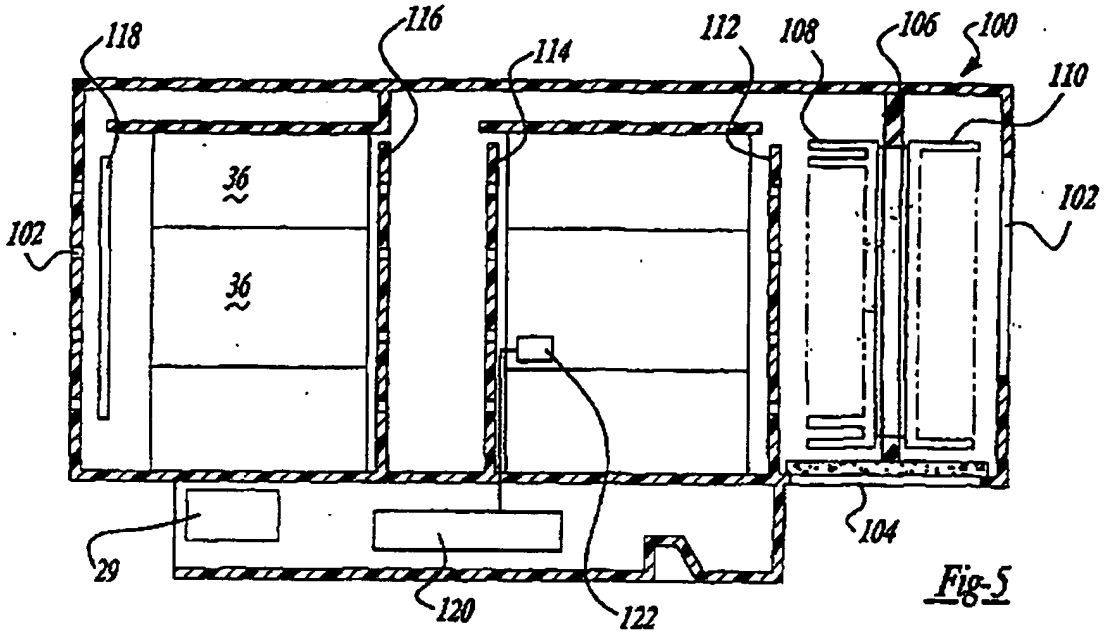


Fig-5

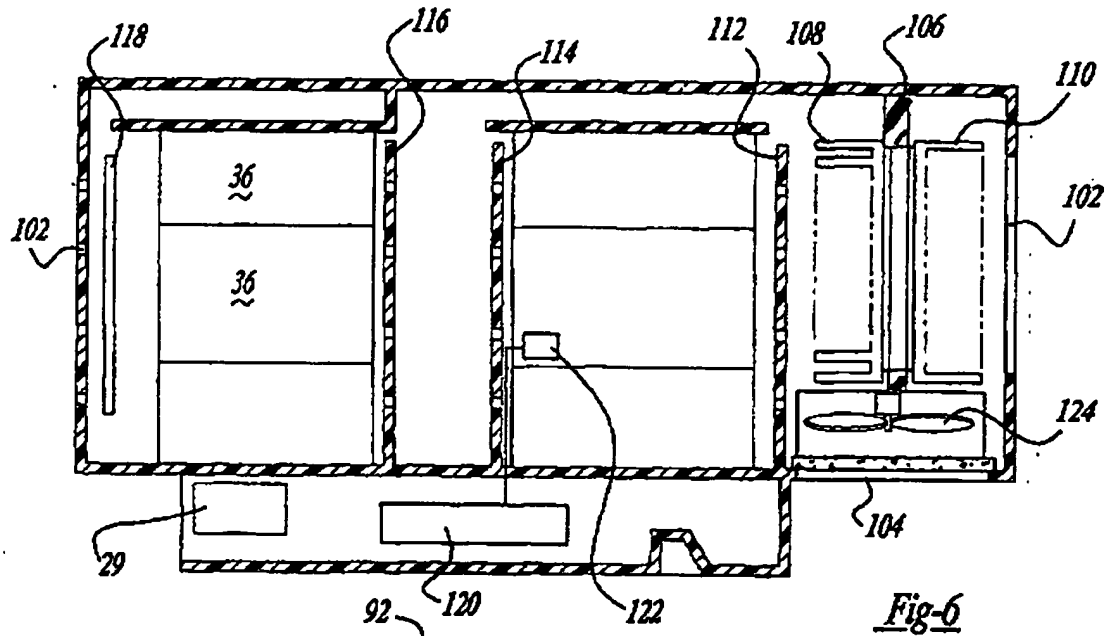
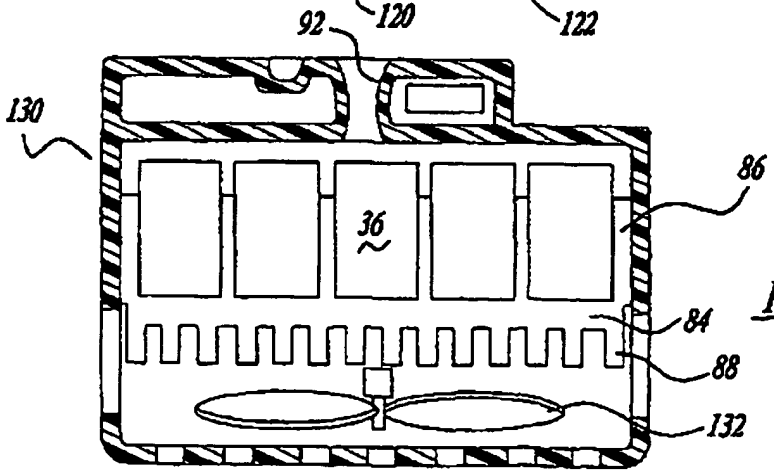


Fig-6



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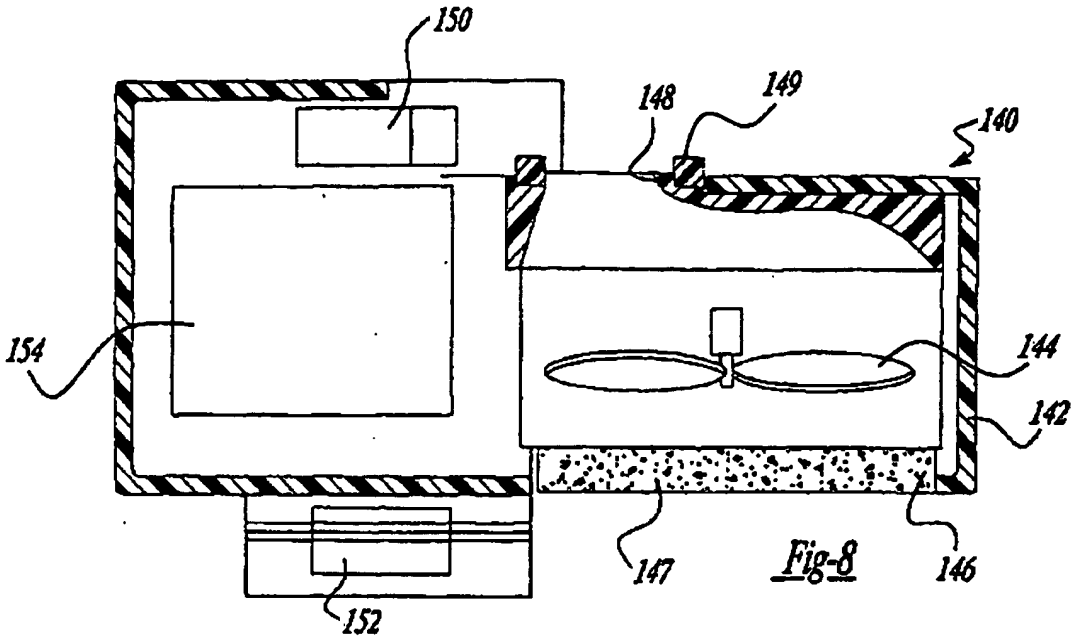


Fig-8

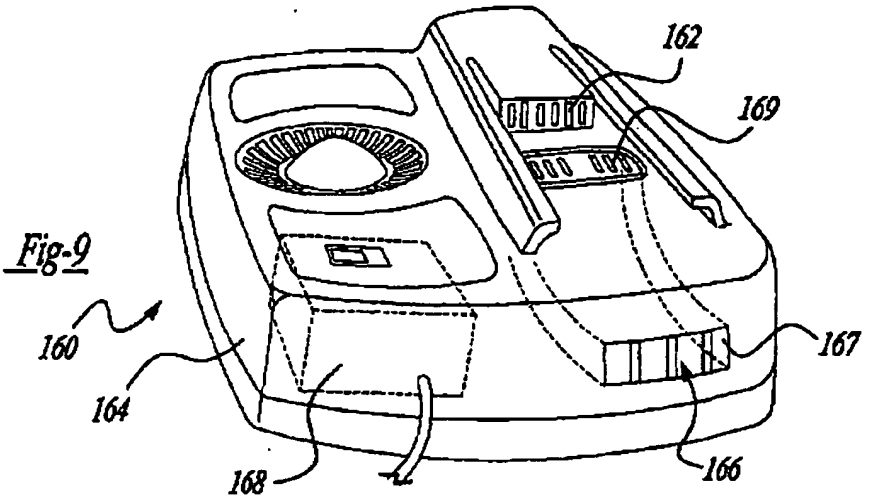


Fig-9

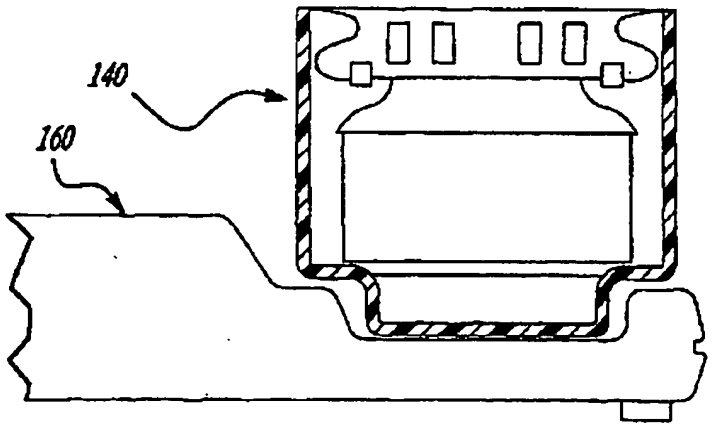


Fig-10

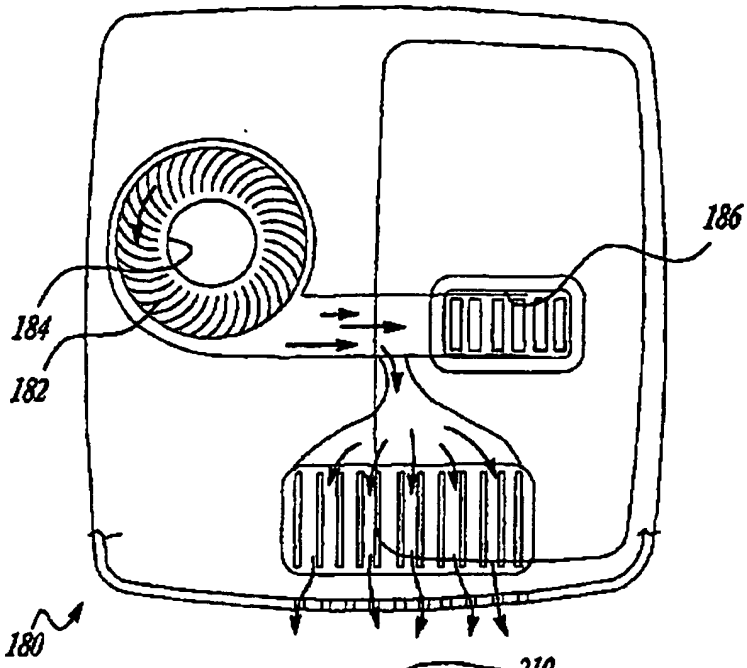


Fig-11

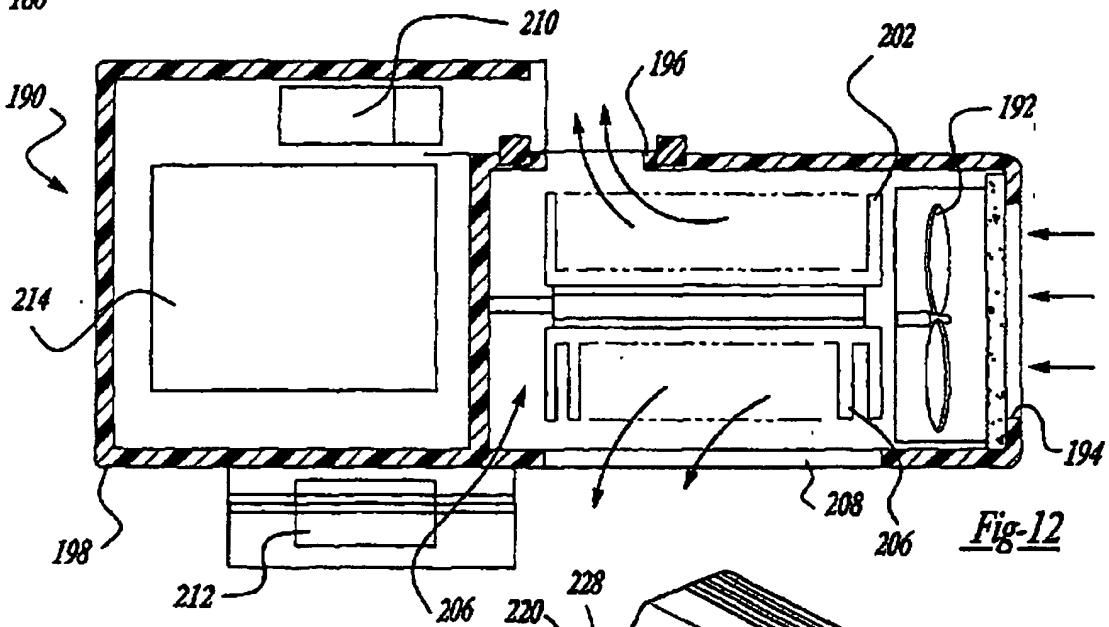
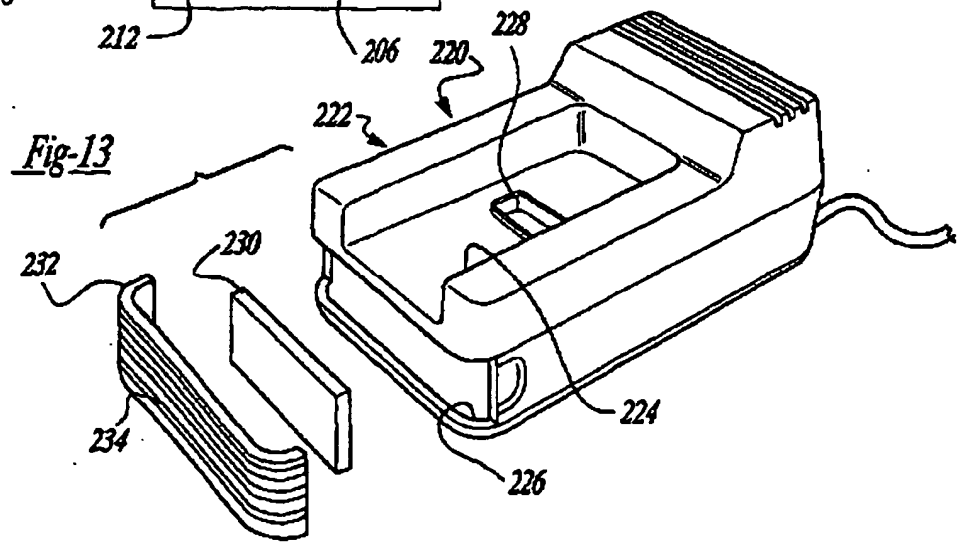


Fig-12

Fig-13



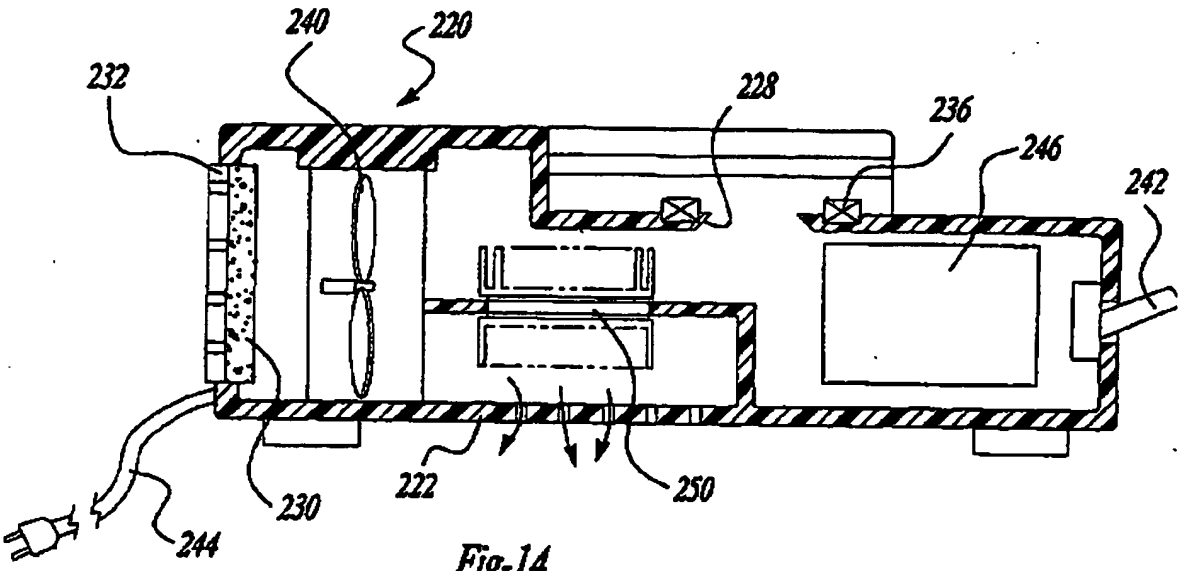

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Fig-14

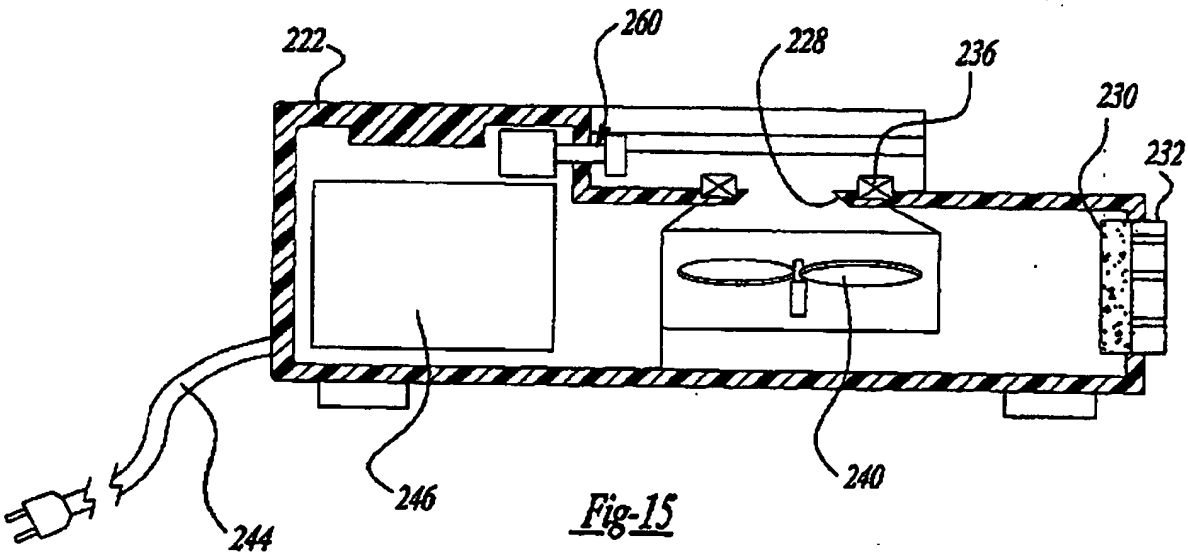
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Fig-15